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Rocky Mountain Forest and
Range Experiment Station
Forest Service
U.S. Department of Agriculture
Fort Collins, Colorado 80521

Forest Vegetation of the Bighorn Mountains, Wyoming: A Habitat Type Classification

USDA Forest Service
Research Paper RM-170

August 1976

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Abstract

Hoffman, George R., and Robert R. Alexander.
  1976. Forest vegetation of the Bighorn Mountains, Wyoming: A habitat type classification. USDA For. Serv. Res. Pap. RM-170, 38 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 80521.

A vegetation classification based on concepts and methods developed by Daubenmire was used to identify 14 habitat types and related phases in the Bighorn Mountains of north-central Wyoming. Included were five habitat types in the *Pinus ponderosa* series, three in the *Abies lasiocarpa* series, two each in the *Pseudotsuga menziesii* and *Pinus contorta* series, and one each in the *Populus tremuloides* and *Picea engelmannii* series. A key to identify the habitat types and the management implications associated with them are provided.

Keywords: Vegetation classification, *Abies lasiocarpa, Picea engelmannii, Pinus contorta, Pinus ponderosa, Pseudotsuga menziesii, Populus tremuloides.*

Foreword

In 1972 Prof. Hoffman began a detailed study of the forest vegetation of the Bighorns under a cooperative agreement with the U.S. Forest Service Region 2 and the Rocky Mountain Forest and Range Experiment Station. The results reported here are intended for two primary audiences: forest managers who want a working tool to use in the Bighorn Mountains, and ecologists who want a research tool to use in related studies. Thus management implications are included for the foresters, and detailed undergrowth data are tabulated in the appendix for the ecologists. Not all readers will find each category of information to be of equal value. We have spelled "Bighorn" as one word throughout the report for consistency; we recognize that "Big Horn" is also appropriate for several geographic names.

About the cover -

High elevation vegetation of the Bighorn Mountains. Coniferous forests here are dominated by *Pinus contorta, Picea engelmannii* and *Abies lasiocarpa.* These forests form a mosaic with parks dominated by herbaceous vegetation in the foreground, while in the background they are interspersed with fewer parks. Cloud Peak Wilderness Area is in far background.

Forest Vegetation of the Bighorn Mountains, Wyoming: A Habitat Type Classification

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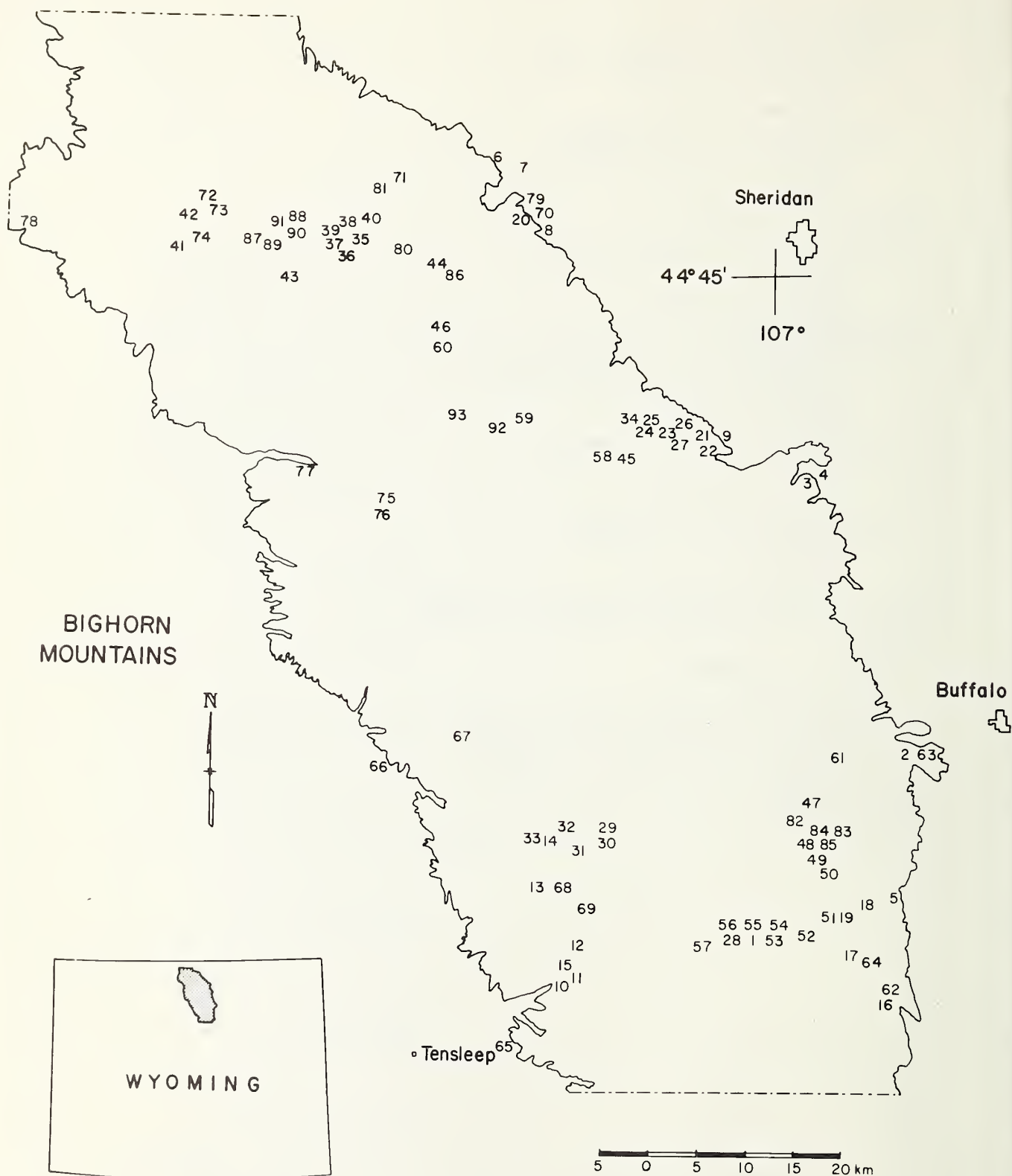Rocky Mountain Forest and Range Experiment Station[1]

CONTENTS

Figure 1.—Bighorn Mountain study area; numbers indicate location of study plots.

George R. Hoffman and Robert R. Alexander

The forest vegetation of the Bighorn Mountains in north-central Wyoming has been studied less intensively than vegetation elsewhere in the Rocky Mountains. While forest vegetation of the Bighorns is similar in many respects to that of the main Cordilleran chain, there are important differences because this isolated spur of mountains some 280 km (175 miles) east of the main Rockies is surrounded by steppe and shrub-steppe vegetation.

Earlier studies in the Bighorn Mountains emphasized the quality, abundance, and distribution of important forest trees; grazing potential of understory vegetation (Town 1899, Jack 1900); and the relationship of vegetation to climate and soils (Rolston 1961, Despain 1973). The general vegetation zonation is similar to much of the Rockies (Daubenmire 1943, Porter 1962), but no attempt has been made to classify these forests into units of similar vegetation and like biological potential.

This cooperative study was started in 1972 to (1) identify and describe forest habitats of the Bighorns, (2) describe successional patterns of forest vegetation, (3) relate topographic and edaphic factors to the habitat types, and (4) relate Bighorn habitat types to those of surrounding areas. The habitat type classification, completed in 1975,[2] is based on concepts and methods developed by Daubenmire (1952) and extended and modified by Daubenmire and Daubenmire (1968), Reed (1969), Pfister and others (1974) and Wirsing and Alexander (1975).

THE STUDY AREA

Geography and Geology

The Bighorn Mountains of north-central Wyoming are bordered on the east by the Powder River Basin and on the west by the Bighorn River Basin (fig. 1). On the north are the Pryor Mountains, while the Owl Mountains lie to the southwest. The east and west basins range in elevation from 900 to 1,200 m (2,952 to 3,936 ft). The Bighorn Mountains rise from the plains to a maximum elevation of 4,016 m (13,172 ft) at the summit of Cloud Peak. The total mountain range is some 190 km (120 miles) long and 30 to 50 km (20 to 30 miles) wide.

The Bighorn Mountain range, a relatively simple asymmetric anticline, is naturally divided into northern, middle, and southern segments. During formation, the northern and southern segments were thrust to the west and the middle segment was thrust to the east. In the middle segment, the exposed core of Precambrian granites forms the highest peaks. The northern and southern segments are overarched by sedimentary rock that forms elevated plateaus. Steeply inclined sedimentary strata flank the core on the east and west. Some glaciation occurred during the Pleistocene, but glaciers extending downslope did not reach the basin floor.

Climate

Precipitation in the Bighorn Mountains increases with elevation. Mean annual precipitation varies from about 38 cm (15 inches) at 1,524 m (5,000 ft) elevation in the *Pinus ponderosa* forest zone to about 63 cm (25 inches) at 2,744 m (9,000 ft) in the *Picea engelmannii-Abies lasiocarpa* forest zone. At lower elevations, most precipitation falls as rain during the months of April through September. At the higher elevations, precipitation is more equally distributed throughout the year, but a higher proportion falls as snow.

Mean annual temperature in the *Pinus ponderosa* zone is about 7°C with a maximum range of -40°C to 43°C. In the *Picea engelmannii-Abies lasiocarpa* forest zone, mean annual temperature is about 2°C

with a range of -46°C to about 32°C. Climographs (fig. 2) describe mean temperature and precipitation of the eastern and western basal plains, lower timberline on the eastern flank of the mountains, and the *Abies lasiocarpa* zone.

METHODS

Field Sampling

Preliminary work in the Bighorn Mountains was begun in the summer of 1972 with a reconnaissance survey to gain familiarity with possible forest habitat types, and to collect plant species throughout the various habitat types. A list of possible study sites was noted with brief descriptions.

During the summers of 1973 and 1974, field work was conducted in 93 stands selected for intensive sampling. These stands were mostly old-growth and climax or in late seral stages of succession. They were representative of the forest communities characterized by the following tree species: *Pinus ponderosa, Pseudotsuga menziesii, Populus tremuloides, Pinus contorta, Abies lasiocarpa* and *Picea engelmannii.*

In each stand, a 15-by 25-m plot was laid out with the long dimension parallel to the contour, and so located in the stand to avoid ecotones and disturbances. Each 375 m² plot was then subdivided into three 5-by 25-m macroplots. Within each 375-m² plot, all trees taller than 1 m were measured at breast height and recorded by 1-dm classes. Trees less than 1 m tall were counted in two 1-by 25-m transects along the inner sides of the central macroplot.
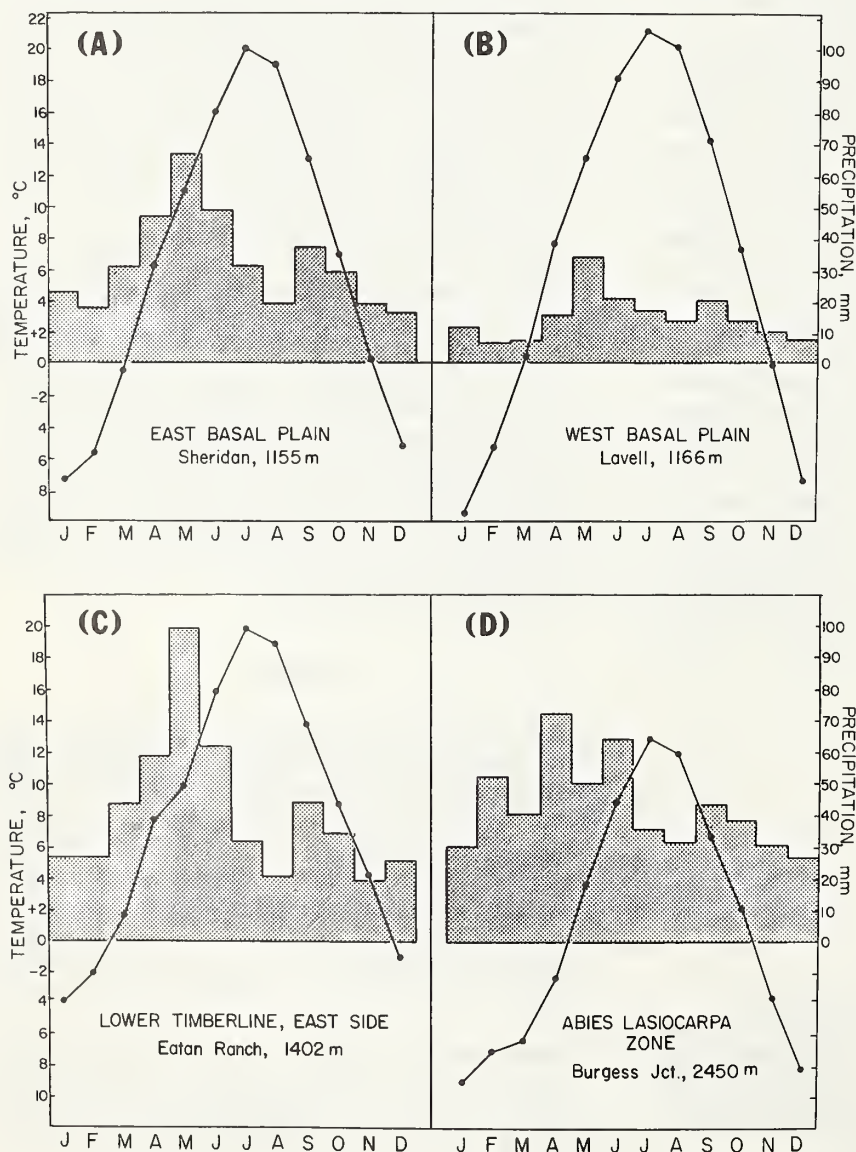

Figure 2.—Climographs of mean temperature and precipitation from **(A)** east basal plain, **(B)** west basal plain, **(C)** lower timberline along eastern flank, and **(D)** *Abies lasiocarpa* zone near Burgess Junction.

Canopy cover of the understory shrubs, forbs, and graminoids was estimated in fifty 2-by 5-dm microplots placed systematically along the inner sides of the central macroplot. Canopy coverage of each species was recorded as one of six coverage classes (1-5, 6-25, 26-50, 51-75, 76-95, 96-100 percent). Also listed were those species not occurring in the 50 microplots, but present within the 375-m² plot.

Finally, 25 cores representing the upper dm of the mineral soil were collected from each stand. These samples were air dried in the field, then composited for laboratory analysis.

Analysis of Data

Tree size class data were combined according to habitat type, and mean values for each size class in each habitat type were recorded. (Table 3, appendix).

For each microplot examined, the midpoints of the coverage classes were used to calculate average percent coverage for each shrub, graminoid, and forb species. Frequency was also determined for each species. (Coverage and frequency data for all understory species plus site data are shown in tables 4 through 8 in the appendix). Species coverage and selected stand characteristics were then transferred to an association table. Stands were arranged and rearranged to group stands with similar floristic composition and climax tree species. Habitat type separation was based on a consideration of both overstory and major shrubs, graminoids, and forbs. Finally, distinctive minor floristic differences were used to differentiate phases. (For further details on the method of analysis see Daubenmire 1952 and Daubenmire and Daubenmire 1968).

Soil texture was determined by a modified Bouyoucos method (Moodie and others 1963). Other soil characteristics determined were pH (using a glass electrode on the saturated soil paste), cation exchange capacity, and exchangeable Ca, Mg, K, and Na on the ammonium acetate extract. Kjeldahl N and P were determined by the Bray technique (Chapman and Pratt 1961).

Ecologic Terms and Concepts

Because terminology in ecology is not uniformly used or understood, the terms and concepts used in this paper are defined as follow. Unless stated otherwise, all terms follow usage proposed by Daubenmire (1968) and Daubenmire and Daubenmire (1968).

Climax vegetation is that which has attained a steady state with its environment; species of climax vegetation successfully maintain their population sizes. **Seral communities** are stands of vegetation that have not attained a steady state; current populations of some species are being replaced by other species. All stands of climax vegetation that have the same overstory and understory dominants are grouped into a single **plant association.** Plant associations having the same overstory (climax) dominants are grouped into **series.**

Much of the Bighorn region has been disturbed by fire, logging, and grazing for many years. Due to disturbance, much of the land area does not currently support climax vegetation. However, that land area which either supports, or has the potential of supporting, a single plant association is called a **habitat type.** It is possible that much of the area of a habitat type will never attain climax status. Nevertheless, it is important to consider land units in terms of their potential status. Tree productivity, disease and insect susceptibility, (Daubenmire 1961), and microclimate and soils are often closely related to habitat types. From the standpoint of basic as well as applied ecology, the habitat type concept offers a useful approach in dealing with forest resources.

Habitat type is the basic unit in classifying natural vegetation. **Series** is the next higher category of classification. For example, all habitat types with *Pinus ponderosa* the climax dominant, are grouped into the *Pinus ponderosa* series. The series is more than an artificial grouping of vegetation types using the climax dominant as the convenient thread of continuity. There is ecologic basis for grouping vegetation types into series as defined here. For example, *Pinus ponderosa* occupies areas that are warmer and drier than areas where *Pseudotsuga menziesii* is climax. Continuing higher into the mountains, *Pinus contorta, Picea engelmannii,* and *Abies lasiocarpa* successively become the dominant species. In the absence of concrete data for the Bighorns, it is assumed that these self-perpetuating populations of dominant trees are related to the macroclimate, whereas the understory vegetation is related more to microclimate and soils. Stands in a series have the same general appearance whether they are in the Bighorns or in nearby forests of Wyoming, southern Montana, and western South Dakota. Habitat types within a series are differentiated on the basis of understory vegetation.

THE HABITAT TYPES

Pinus ponderosa Series

This series, represented by 10 plots, occurs within a range of environmental conditions where *Pinus ponderosa* is the only self-perpetuating tree species (table 1).

Table 1.--Selected topographic and edaphic characteristics of the habitat types of the Bighorn Mountains

Habitat type	Number of stands studied	Elevation	Soil texture[1]	pH[1]	Organic matter
		Meters			*Percent*
Pinus ponderosa/ Agropyron spicatum	1	1829	Sandy loam	6.1	1.76
Pinus ponderosa/ Festuca idahoensis	2	1311-1818	Loamy sand- sandy loam	6.1-6.5	3.45- 6.21
Pinus ponderosa/ Spiraea betulifolia	2	1731-1798	Sandy loam	6.1-7.4	5.63-12.30
Pinus ponderosa/ Physcocarpus monogynus	4	1402-1804	Loamy sand- loam	5.9-7.1	3.65-12.30
Pinus ponderosa/ Juniperus communis	1	2341	Silt loam	6.8	8.57
Pseudotsuga menziesii/ Physocarpus monogynus	3	1878-2012	Loam-silt loam	6.8-7.1	7.28-11.40
Pseudotsuga menziesii/ Berberis repens	8	2158-2609	Loam-silt loam	6.4-7.7	5.60-11.50
Pseudotsuga menziesii/ Berberis repens- Juniperus communis phase	2	2286-2365	Loamy sand- clay loam	6.3-6.5	2.33- 5.05
Populus tremuloides/ Lupinus argenteus	4	2140-2365	Clay loam	5.9-6.7	11.30-12.30
Pinus contorta/ Arctostaphylos uva-ursi	5	2390-2512	Sandy loam- loam	5.4-5.6	1.71- 4.50
Pinus contorta/ Vaccinium scoparium	11	2341-2640	Sandy loam- silt loam	5.0-5.7	5.59- 7.91
Picae engelmannii/ Vaccinium scoparium	10	2012-2621	Sandy loam- silt loam	5.0-5.7	0.57-12.30
Abies lasiocarpa/ Shepherdia canadensis	2	2524-2560	Silt-loam clay loam	5.5-5.7	4.30- 5.98
Abies lasiocarpa/ Vaccinium scoparium	25	2300-2830	Sandy loam- clay loam	4.9-5.8	2.37-11.10
Abies lasiocarpa/ Arnica cordifolia	7	2548-2731	Silty clay loam clay loam	5.1-6.6	7.94-12.80

[1]Upper 1 dm of soil.

Following disturbance in the Bighorn Mountains, *Pinus ponderosa* rapidly reestablishes itself with little or no competition from other tree species, except for an occasional *Populus tremuloides*. Along the eastern flank of the Bighorns, a well-developed belt of *Pinus ponderosa* forest occurs on coarse-textured soils at the lower limits of coniferous tree growth. Along the southwestern segment of the Bighorns, there is a narrow belt of climax *Pinus ponderosa* forest. However, because of its limited extent and open-grown character, no stands were sampled. These *Pinus ponderosa* stands show no evidence of succession toward a *Pseudotsuga menziesii* forest. Most of the *Pinus ponderosa* along the western side of the mountains, however, appears to be seral to *Pseudotsuga menziesii*. (Tree population data and undergrowth data for *Pinus ponderosa* stands are recorded in the appendix, tables 3 and 4, respectively).

Five habitat types are recognized in the series. Basal areas of *P. ponderosa* in the study plots ranged from 16 to 60 m²/ha (71 to 262 ft²/acre). Age measured at breast height, varied from 58 to 280 years, with a median age of 97 years. The full extent of the habitat types in this series is difficult to determine because of repeated and widespread fires in the late 1800's and early 1900's.

Pinus ponderosa/Agropyron spicatum

Description.—Only one stand of the *Pinus ponderosa/Agropyron spicatum* habitat type was sampled, but numerous others were observed (fig. 3). This habitat type occurs almost entirely below the National Forest boundary. It is the driest and warmest within the *Pinus ponderosa* series, and occupies south-facing slopes along the eastern flank of the Bighorn Mountains.

Due to the harsh microclimate of this habitat type, tree reproduction has been sporadic, resulting in open patches of even-aged trees. These widely spaced trees permit considerable radiation to reach the ground. The xeric nature of this habitat type permits a luxuriant growth of sun-tolerant understory species.

The understory is conspicuously dominated by such graminoids as *Agropyron spicatum, Aristida longiseta, Carex filifolia, Koeleria cristata,* and *Stipa comata.* Shrubs occuring in 4 percent or more of the microplots are *Artemisia frigida* and *Prunus virginiana.* Important forb species are *Viola nuttallii, Antennaria parviflora, Balsamorhiza sagittata* and *Astragalus succulentus.*

This habitat type is common in Montana (Pfister and others 1974), and in eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968).

Figure 3.—*Pinus ponderosa/Agropyron spicatum* habitat type as it occurs near lower timberline in the Bighorns. Note the widely-spaced trees and the abundance of the large forb, *Balsamorhiza sagittata,* at this location.

5

Management Implications.—The *Pinus ponderosa/Agropyron spicatum* habitat type is marginal for timber production. Cutting will be largely for scenic and recreation purposes or to improve forage production. Stands can be harvested by removing the older, less vigorous, and diseased trees by individual tree or group selection, or a shelterwood system can be used where stand conditions permit. Tree reproduction is likely to be difficult to obtain because of severe competition from understory species for limited soil moisture. This habitat type is one of the best for livestock production. Herbage production will vary from little or nothing on depleted ranges to as much as 840 kg per ha (1,500 lbs/acre) under proper grazing management. Big game forage production is low, but the winter demand by big game may be relatively high, resulting in competition between big game and domestic animals. Annual runoff is less than 13 cm (5 inches) and the potential for increasing streamflow by timber harvesting is low. The potential recreation and scenic values of this habitat type are relatively high.

Pinus ponderosa/Festuca idahoensis

Description.—The *Pinus ponderosa/Festuca ida-hoensis* habitat type occupies less xeric areas than the previous habitat type. It is characterized by an understory dominated by *Festuca idahoensis* (fig. 4). Other important graminoids are *Carex filifolia*, *Agropyron spicatum*, *Bromus tectorum*, *Hespero-chloa kingii*, and *Koeleria cristata*. *Poa palustris*, *P.*

pratensis, and *Stipa viridula* are less conspicuous. Important shrub and forb species include *Rhus trilobata*, *Prunus virginiana*, *Artemisia frigida*, *Rosa acicularis*, *Symphoricarpos albus*, *Balsamorhiza sagittata*, *Cerastium arvense*, *Cystopteris fragilis*, *Achillea millefolium*, *Anemone patens*, *Antennaria rosea*, and *Astragalus succulentus*.

This habitat type, represented by two stands in the Bighorn Mountains, occurs on well-drained soils on the warmer, drier slopes, and can occur adjacent to the *P. ponderosa/Spiraea betulifolia* and *P. ponder-osa/Physocarpus monogynus* habitat types.

Although tree reproduction is more consistent over time than in the *P. ponderosa/Agropyron spicatum* habitat type, it seems to follow an episodic cycle. The cycle may be due to the relatively low rainfall in most years which influences seed production and seedling establishment, or to fires which destroy tree seedlings. With the increase in fire protection, both graminoids and forbs compete more effectively than tree seedlings for limited soil moisture.

The *P. ponderosa/Festuca idahoensis* habitat type has also been reported in Montana (Pfister and others 1974), and in eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968).

Management Implications.—The management implications for this habitat type are similar to the *Pinus ponderosa/Agropyron spicatum* habitat type. Forage production for livestock will be higher, however, ranging from 840 to 1,680 kg of herbage per hectare (1,500 to 3,000 lbs/acre), depending .upon range condition and grazing practices.

Figure 4.—*Pinus ponderosa/Festu-ca idahoensis* habitat type. Near the large pine in the left fore-ground are *Prunus virginiana* and *Rhus trilobata*. (A 1-m stake is used for scale in this and subse-quent photographs.)

Pinus ponderosa/Spiraea betulifolia

Description.—This habitat type, which occurs on more mesic sites than either of the previous habitat types, is represented by two stands confined to the eastern slopes of the Bighorn Mountains.

The understory vegetation is a mixture of grasses, perennial forbs, and low shrubs. The dominant species are *Spiraea betulifolia* and *Symphoricarpos albus* (fig. 5). Other shrubs include *Berberis repens,*[3] *Potentilla fissa,* and *Prunus virginiana.* The principal grasses present are *Festuca idahoensis, Hesperochloa kingii,* and *Poa palustris. Poa interior* occurs in this habitat type, but is common in the more mesophytic habitat types. Important forbs are *Clematis tenuiloba, Galium boreale, Balsamorhiza sagittata, Lomatium dissectum, Lupinus argenteus,* and *Smilacina racemosa.* Conspicuous by their absence are *Rhus trilobata, Agropyron spicatum, Aristida longiseta, Artemisia frigida, Astragalus succulentus,* and *Physocarpus monogynus.*

Figure 5.—*Pinus ponderosa/Spiraea betulifolia* habitat type. Various size classes of the dominant tree occur at this site.

Due to the more mesophytic habitat, the overstory has a more closed structure and tree reproduction is more abundant than in the previous habitat types.

Similar habitat types have been observed elsewhere. Thilenius (1971) in the Black Hills and Pfister and others (1974) in Montana have described a *Pinus ponderosa/Symphoricarpos albus* habitat type which shares many of the species common to the *Pinus ponderosa/Spiraea betulifolia* habitat type in the Bighorn Mountains.

Management Implications.—The *Pinus ponderosa/Spiraea betulifolia* habitat type is one of the better timber-producing types in the *P. ponderosa* series. On areas harvested for timber, shelterwood and group and individual tree selection cutting may be used depending upon the age, health, and vigor of the stand, and land management objectives. Natural regeneration will usually restock the stands. Stand density should be kept at levels lower than the optimum for timber production to maintain forage production and minimize damage from bark beetle attacks. Livestock forage production is variable and depends upon the density and composition of grass cover, and overstory density. Big game forage production is higher than on the more xerix habitat types, and winter use by deer may be heavy. With less than 13 cm (5 inches) of annual runoff, the potential for increasing streamflow by timber harvesting is low. The potential recreation and scenic values of this habitat type are relatively high.

Pinus ponderosa/Physocarpus monogynus

Description.—The *Pinus ponderosa/Physocarpus monogynus* habitat type, confined to the east slope, occupies the most favorable sites on which *Pinus ponderosa* attains climax status in the Bighorn Mountains. The four stands sampled occurred on northerly aspects that receive little or no direct solar radiation. At lower elevations or on drier sites, this habitat type grades into either the *P. ponderosa/ Spiraea betulifolia* or *P. ponderosa/Festuca idahoensis* habitat types (fig. 6). Of the stands sampled, two were younger than 100 years and developed after fires, and two were older than 200 years.

Understory vegetation, dominated by the shrub *Physocarpus monogynus,* is relatively rich in species (fig. 7). Many of these species are also common in the *P. ponderosa/Spiraea betulifolia* habitat type. *Physocarpus monogynus, Acer glabrum,* and *Amelanchier anifolia* are shrubs that occur in this habitat type, but are not found in other *P. ponderosa* habitat types. Other common undergrowth species include *Clematis tenuiloba, Berberis repens, Rosa acicularis, Spiraea betulifolia* and *Symphoricarpos albus.* Important grasses and forbs are *Festuca idahoensis, Hesperochloa kingii, Poa interior, P. palustris, Antennaria rosea, Balsamorhiza sagittata, Cerastium arvense, Cystopteris fragilis, Galium boreale,* and *Lupinus argenteus.* Among the more important graminoids and forbs of this habitat type that do not occur in other *P. ponderosa* habitat types are *Carex xerantica, Stipa columbiana, Aster conspicuus, Epilobium angustifolium,* and *Fragaria*

[3]Mahonia repens *in tables 3 through 6 (Appendix) should be* Berberis repens.

Figure 6.—*Pinus ponderosa/ Physocarpus monogynus* habitat type. **A.** At its xeric limit, the *Physocarpus* shrub layer is somewhat dwarfed and attains a height of 2-3 dm. **B.** Under more favorable moisture conditions the *Physocarpus* can reach a height of about 7 dm.

Figure 7.—There is considerable floristic similarity between the *Spiraea betulifolia* union and the *Physocarpus monogynus* union shown here; both are rich in species. Shown here are *P. monogynus, S. betulifolia, Symphoricarpos albus, Galium boreale,* and *Aster* spp. Note the abundant pine litter and duff covering the mineral soil.

virginiana. Arnica cordifolia also occurred in the younger stands but was not found elsewhere in the *P. ponderosa* series.

There is no counterpart to this habitat type in the Black Hills or in southeastern Montana. In Montana, however, Pfister and others (1974) described a *Pinus ponderosa/Prunus virginiana* habitat type which shares many of the species common to the *Pinus ponderosa/Physocarpus monogynus* habitat type of the Bighorn Mountains. The *Pinus ponderosa/Physocarpus malvaceus* habitat type in eastern Washington and northern Idaho described by Daubenmire and Daubenmire (1968) is closely related.

Management Implications.—The management implications for this habitat type are similar to those for the *Pinus ponderosa/Spiraea betulifolia* habitat type, except that it is potentially the best timber producer in the *P. ponderosa* series. If higher stand densities are maintained for timber production, forage production for livestock is likely to be reduced. Browse production may be higher and provide a potential for winter use by deer.

Pinus ponderosa/Juniperus communis

Description.—The *Pinus ponderosa/Juniperus communis* habitat type is limited to the southeastern segment of the Bighorn Mountains. Only one stand was sampled, but others were observed. The understory is sparse and floristically poor, but tree seedlings are establishing successfully.

Juniperus communis is the dominant understory species; important grasses and forbs are *Hesperochloa kingii, Poa interior, Agoseris glauca, Astragalus miser, Lonatium ambiguum,* and *Clematis tenuiloba.*

A habitat type with similar understory vegetation was not reported for Montana (Pfister and others 1974) or eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968). Thilenius (1971), however, described a habitat type in the Black Hills in which understory vegetation was dominated by both *Juniperus communis* and *Berberis repens.*

Management Implications.—Relatively little information is available on the management of this habitat type. Timber productivity is less than average for the *P. ponderosa* series. Natural reproduction appears to be less difficult to obtain than in those habitat types where the understory is dominated by graminoids. Timber can be harvested by shelterwood, and group and individual tree selection. Forage production and natural runoff are low. The potential for increasing these resources does not appear to be great.

Pseudotsuga menziesii Series

This series, represented by 13 plots, occurs where favorable soil moisture balance permits *Pseudotsuga menziesii* to replace *Pinus ponderosa* as the climax species (table 1). In the Bighorn Mountains *P. menziesii* is the climax dominant at intermediate elevations of 1,878 to 2,609 m (6,160 to 8,558 ft) and occurs most frequently on soils developed from limestone or dolomite. In these habits *Pinus ponderosa, Pinus flexilis, Pinus contorta,* and occasionally *Populus tremuloides* may be present in any combination as seral species.

P. menziesii is a climax species on both the east and west sides of the mountains. On the west side it commonly forms the lowest coniferous forest zone. On the east side, it occupies a position on the moisture-temperature gradient intermediate between *P. ponderosa* and *P. contorta* forests. At lower elevations along the western slope *P. menziesii* varies from a climax to a seral species. In the more moist habitats *Picea engelmannii* is climax to the lowest elevation of coniferous forests.

Two habitat types and one phase have been recognized. Basal areas of *P. menziesii* on the study plots ranged from 13 to 95 m²/ha (58 to 414²/acre). Age measured at breast height varied from 60 to 247 years, with a median age of 129 years. (Tree population data and undergrowth data for *Pseudotsuga menziesii* stands are recorded in appendix tables 3 and 5 respectively.)

Pseudotsuga menziesii/Berberis repens

Description.—The *Pseudotsuga menziesii/Berberis repens* habitat type, represented by eight stands, is widespread on sedimentary shales and sandstones, and glacial moraines in the Bighorn Mountains (fig. 8). It is recognized by the consistent presence and reproductive success of *P. menziesii,* and by the abundance and dominance of *Berberis repens.* Other important species in the mixed shrub, forb, and grass understory are *Ribes lacustre, Juniperus communis, Symphoricarpos oreophilus, Hesperochloa kingii, Poa* spp., *Arnica cordifolia, Galium boreale, Senecio streptanthifolius,* and *Smilacina racemosa.*

Biotic succession following disturbance involves both the reestablishment of *P. menziesii* and the invasion of seral species. A clear example of primary succession of this habitat type, rather than reestablishment, occurs along both slopes of Tensleep Canyon (fig. 9). It is characterized by the direct invasion of the *Artemisia tridentata* shrub-steppe community by *Pseudotsuga menziesii* and *Pinus flexilis,* or the initial establishment of *Juniperus*

Figure 8.—*Pseudotsuga menziesii/Berberis repens* habitat type. **A.** The *Berberis* union is a rich mixture of low-growing shrubs and herbaceous species. **B.** Some of the largest trees in the Bighorns are *Pseudotsugas* occurring on sites where neither fire nor logging has been a disturbing factor for hundreds of years. Having become established in the shade of a now dead *Juniperus,* the remains of which still exist near the base of the tree, this *Pseudotsuga* provided the seed source for most of the trees forming the closed community here.

Figure 9.—*Artemisia tridentata*-dominated shrub-steppe of Tensleep Canyon. **A.** Succession of *Pseudotsuga menziesii* into shrub-steppe. **B.** Large *Artemisia* shrub on left provided a suitable micro-climate in which *Pseudotsuga* seedling, just to left of stake, became established.

communis which provides a suitable microhabitat for the establishment of *P. menziesii*. Throughout much of the *Artemisia*-dominated slopes, *Berberis* and other members of the undergrowth union are becoming established (fig. 10). This may indicate a gradual shift from shrub-steppe dominated by *Artemisia tridentata* to coniferous forest dominated by *Pseudotsuga menziesii*, provided that the climate is becoming cooler and more moist over time.

Reed (1969) reported a similar habitat type (*Pseudotsuga menziesii/Symphoricarpos oreophilus* in the Wind River Mountains of Wyoming that shares many of the important understory species. The *P. menziesii/Spiraea betulifolia* and *P. menziesii/Arnica cordifolia* habitat types of Montana (Pfister and others 1974) are also similar to the *P. menziesii/Berberis repens* habitat type in the Bighorns.

Figure 10.—*Berberis repens* on the right is invading the *Artemisia tridentata*-dominated shrub-steppe in Tensleep Canyon. The large shrub on the left is *A. tridentata*. Photograph was taken about 50 meters from nearest stand of *Pseudotsuga menziesii/Berberis repens*.

Juniperus communis Phase.—The most xeric habitats on which *P. menziesii* maintains climax status are on the southeastern flank and along low summits of the southern ridges of the Bighorns. Soils are usually fine textured and droughty. *Pinus ponderosa* and *P. flexilis* are usually present as seral species (fig. 11).

The understory in the two stands sampled is characterized by *Juniperus communis*. Other conspicuous understory species are *Berberis repens*, *Rosa acicularis*, *Symphoricarpos oreophilus*, *Hesperochloa kingii*, *Festuca ovina*, *Arnica cordifolia*, *Astragalus miser*, *Galium boreale*, and *Lupinus argenteus*.

In Montana, Pfister and others (1974) recognized a *P. menziesii/Juniperus communis* habitat type. With additional study, the *Juniperus* phase of the *P. menziesii/Berberis repens* habitat type in the Bighorns may warrant recognition as a separate habitat type.

A *Juniperus osteosperma* phase of the *Pseudotsuga menziesii/Berberis repens* habitat type may exist along the west slopes of the Bighorns. A closer examination of stands with a conspicuous amount of *J. osteosperma* is necessary before these stands could be separated in the forest classification scheme.

Figure 11.—*Pseudotsuga menziesii/Berberis repens* habitat type, *Juniperus communis* phase. Though usually present in scattered patches, *Juniperus* here is present in a more continuous ground cover. Underneath the *Juniperus* are representatives of the *Berberis* union.

Management Implications.—Timber productivity in this habitat type and its phase are generally below average for the *P. menziesii* series. Site conditions are somewhat severe, and regeneration is likely to be difficult to obtain if stands are clearcut, especially where the habitat type is adjacent to mountain grasslands that can invade and occupy the site. Group selection and shelterwood cutting are closer to the regeneration patterns observed in old-growth forests.

Another objective in harvesting timber may be to open up the stands and maintain low basal areas for recreation and scenic purposes. Younger stands provide more forage for livestock and big game than do older stands. The potential for increasing herbage production may be improved by maintaining a low stand density. Where browse species are scarce, deer may use *J. communis* heavily. The potential for increasing streamflow is not much greater than in habitat types dominated by *Pinus ponderosa*.

Pseudotsuga menziesii/Physocarpus monogynus

Description.—The *Pseudotsuga menziesii/Physocarpus monogynus* habitat type, represented by three stands, occurs on the east and west sides of the Bighorn Mountains on northwest- to northeast-facing slopes. The most consistently reproducing tree species is *Pseudotsuga menziesii*, but both *Pinus ponderosa* and *P. flexilis* are common seral species. The understory is dominated by the shrub *Physocarpus monogynus* (fig. 12), with *Berberis repens, Rosa acicularis, Symphoricarpos oreophilus,* and *Spiraea betulifolia* making up the complement of important shrubs.

Figure 12.—*Pseudotsuga menziesii/Physocarpus monogynus* habitat type. The ground cover is dominated by *Physocarpus monogynus* with a rich mixture of dwarf shrubs and forbs under the *Physocarpus*. All size classes of *Pseudotsuga* are also represented.

This habitat type has a more xerophytic character on the west side of the Bighorns than on the east side. Such understory species as *Anemone multifida, Arnica cordifolia, Balsamorhiza sagittata, Clematis tenuiloba,* and *Lomatium dissectum* are important in the understory on the eastern side of the mountains, but not on the west side.

Reed (1969) did not report a *P. menziesii/Physocarpus monogynus* habitat type in the Wind River Mountains. However, Pfister and others (1974) reported a *Pseudotsuga menziesii/Physocarpus malvaceus* habitat type in western and central Montana

on north- and east-facing slopes. In south-central Montana, this habitat type occurs at elevations comparable to the *Pseudotsuga menziesii/Physocarpus monogynus* habitat type in the Bighorns. Daubenmire and Daubenmire (1968) also describe a *P. menziesii/Physocarpus malvaceus* habitat type in eastern Washington and northern Idaho.

Management Implications.—This habitat type is usually the most productive in the *P. menziesii* series, but site indexes may still be relatively low. Where *Pinus ponderosa* is an important seral species, it can be managed by cutting the *P. menziesii* overstory to release the *P. ponderosa*. This simulates the final harvest of a shelterwood system. Otherwise, *P. menziesii* can be managed most successfully by the shelterwood and selection systems that maintain overstory shade. Reproduction is likely to be more difficult to obtain after cutting on the western side of the mountains. Livestock forage production is low, and the potential for any increase is not great. Deer may use the shrub species heavily at times. The potential for increasing natural runoff is higher than in the *Pinus ponderosa* series, but much less than in the higher subalpine forests.

Populus tremuloides Series

Populus tremuloides is not a major tree species in the Bighorn Mountains. It forms small stands and groves within the elevational zones where *Pinus ponderosa* and *Pseudotsuga menziesii* are climax. *P. tremuloides* usually occurs on more mesic habitats with deeper soils, frequently between coniferous forest and natural openings dominated by herbaceous species (see table 1).

This series is represented by four plots, all of which were located in the southern segment of the Bighorns. Most stands of the *P. tremuloides* in the Bighorns are heavily grazed by livestock, which often congregate in these stands during the heat of day.

Only one habitat type has been recognized in this series. Basal areas on the study plots ranged from 22 to 49 m²/ha (98 to 211 ft²/acre) but individual trees never exceeded the 2 to 3 dm (8.0 to 12.0 inch) d.b.h. class. Most reproduction was sprouts. (Tree population data and undergrowth data for *Populus tremuloides* stands are recorded in appendix tables 3 and 6 respectively.)

Populus tremuloides/Lupinus argenteus

Description.—The understory of the *Populus tremuloides/Lupinus argenteus* habitat type consists of a relatively rich mixture of graminoids and forbs

(fig. 13). *Lupinus argenteus, Agropyron spicatum, Carex platylepis, C. scopulorum, Festuca idahoensis, Hesperochloa kingii, Poa nervosa, Achillea mille-folium, Astragalus alpinus, Anemone multifida, Fragaria virginiana, Lupinus wyethii, Taraxacum officinale,* and *Trifolium* spp. are the most characteristic. Shrubs are less important, but *Juniperus communis, Ribes lacustre,* and *Potentilla fruticosa* are conspicuous in some stands. Other understory species favored by disturbance are *Phleum pratense* and *Dactylis glomerata.*

Figure 13.—*Populus tremuloides/Lupinus argenteus* habitat type. As with all *Populus* stands examined, this one has been heavily grazed. Only a limited number of size classes of *Populus* are represented.

In the northern Rockies (Daubenmire and Daubenmire 1968) and in Montana (Pfister and others 1974) there are no habitat types dominated by *Populus tremuloides.* In the Wind River Mountains where *P. tremuloides* is a more important species, Reed (1969) described a *P. tremuloides/Symphoricarpos oreophilus* habitat type. It does not have the same characteristics as the *P. tremuloides/Lupinus argenteus* habitat type, however.

Management Implications.—This habitat type is valuable for the fall color it provides, but is of little value for timber production. In pure stands, aspen

should be managed under a clearcutting system. Where there is a manageable stand of coniferous species in the understory, it can be released by removing the aspen overstory. If it is desirable to perpetuate the aspen under these conditions, the coniferous understory should be removed. Forage production for livestock is variable in this habitat type, depending upon the species composition and range condition. Forage production can be high where there is a good representation of grasses and the range is not overused. This habitat type provides valuable forage for big game animals. Both deer and elk eat *Populus* sprouts. The habitat type is insignificant in terms of water production because of its limited extent.

Pinus contorta **Series**

Pinus contorta is the most abundant forest tree species in the Bighorn Mountains. Its abundance is usually attributed to the widespread occurrence of repeated fires. There is less agreement on its successional status; many ecologists and foresters consider *P. contorta* a seral species, while others consider it to be at least a long-lived subclimax species in some habitats.

Pinus contorta commonly occurs in fire-regenerated even-aged stands, but it can also occur in uneven-aged stands in the Bighorns. The reproductive patterns of *P. contorta* that determines the age-class structure are influenced by soil moisture and cone serotiny. Extensive stands of *P. contorta* occur in the central third of the Bighorns on exposed granites, at elevations of 2,000 m (6,560 ft) to timberline. *P. contorta* is a seral species in all forests dominated by *Picea engelmannii* and *Abies lasiocarpa* at higher elevations, and on more mesic habitats at intermediate elevations. It is also seral to *Pseudotsuga menziesii* at lower elevations or on more xeric habitats.

Seral *P. contorta* is more likely to be even-aged and bear a high proportion of serotinous cones. However, at intermediate elevations there are habitats where *P. contorta* is the dominant self-reproducing species (see table 1). Here it exhibits a population structure of several age classes, and has no competition from its common associates. Climax *P. contorta* stands are likely to contain a high proportion of trees bearing nonserotinous cones.

Where *P. contorta* covers vast areas in the Bighorn Mountains there may be simply no seed source of climax species available for reinvasion. In those situations, *P. contorta* may be a seral species that will occupy the site for several hundred years. Widespread and repeated burning may also have altered the nutrient status and waterholding capacity of the

soil, thereby delaying the establishment of *P. engelmannii* or *A. lasiocarpa* even when a seed source is available.

This series is represented by 16 plots in which two *Pinus contorta*-dominated habitat types have been recognized. Basal areas of *P. contorta* on the study areas ranged from 18 m²/ha to 55 m²/ha (79 to 240 ft²/acre). Age at breast height varied from 62 to 245 years, with a median age of 149 years. (Tree population data and undergrowth data for *Pinus contorta* stands are recorded in appendix tables 3 and 7 respectively.)

Pinus contorta/Arctostaphylos uva-ursi

Description.—This habitat type, represented by five stands, is the warmest, driest, and most frequently burned of the *P. contorta* habitat types. In the Bighorn Mountains, it is confined to soils of granitic origin with low fertility. Where the habitat type occurs on southerly aspects and adjacent to openings, it may occupy a tension zone.

The consistent presence and reproductive success of *P. contorta,* the absence of other tree reproduction, and the understory dominance of *Arctostaphylos uva-ursi* are the diagnostic features of this habitat type (fig. 14). Other important shrub species are *Juniperus communis* and *Spiraea betulifolia.* Common forbs include *Lupinus argenteus, Senecio streptanthifolius,* and *Solidago spatulata.*

Mixed stands in this habitat type are an exception, but overstocked pole stands of pure *P. contorta* are common (fig. 15). Due to the xeric nature of this habitat type, tree reproduction is likely to be sporadic, especially in dense stands where competition for soil moisture is severe.

Figure 14.—*Pinus contorta/Arctostaphylos uva-ursi* habitat type. **A.** The dominant *Pinus* is present in all size classes. The abundance of *Arctostaphylos* and *Lupinus argenteus* and the virtual absence of *Vaccinium scoparium* characterize the ground cover of this habitat type. **B.** Closeup of undergrowth shows the two major ground cover species, *Arctostaphylos* and *Lupinus.*

Figure 15.—Overstocked stand of *Pinus contorta/Arctostaphylos uva-ursi* habitat type. Ground cover is poorly developed because of dense tree growth and extreme shade.
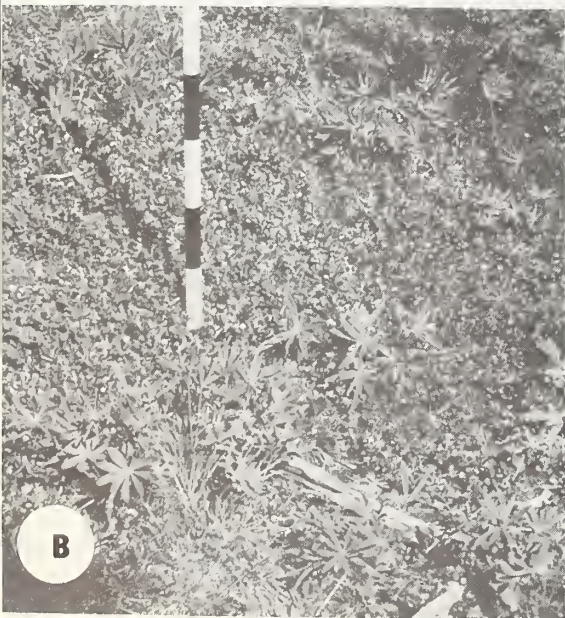
Management Implications.—The *Pinus contorta/ Arctostaphylos uva-ursi* habitat type is reasonably productive for timber, even though site indexes are likely to be below average for the *P. contorta* series (Alexander 1966). Clearcutting or shelterwood cutting can be used in sawlog-sized stands regardless of cone habit. Scarification is likely to be essential for natural regeneration success (fig. 16). On south slopes and in tension zones, a long regeneration period usually follows clearcutting because of limited soil moisture. In those situations, a shelterwood system is more likely to result in regeneration success. On other aspects, clearcutting is usually successful, but can result in either too much or too little reproduction, depending on the cone habit, amount of seed available, and slash disposal treatments (fig. 17) (Alexander 1974). If a clearcut option is used in stands with nonserotinous cones, openings should be in the form of small (3- to 5-acre) patches or narrow (400-ft wide) strips where natural regeneration is desired. Large clearcut openings will require fill-in planting. In stands with serotinous cones,

clearcut openings up to 16 hectares (40 acres) in size may be used if the stand is heavily infected with mistletoe. Care must be used in slash disposal in these stands so that the seed source is not destroyed. Group selection cutting is a possibility in stands with irregular structure, but individual tree selection cutting is generally appropriate only in recreation areas.

In young *P. contorta* pole stands, thinning is needed to reduce basal area and improve soil moisture conditions. Basal area levels of 80 or less are most appropriate (Myers and others 1971).

Forage production is usually increased for a short time following clearcutting, but the potential for increasing forage production for either livestock or big game is limited in this habitat type.

Natural runoff in the *P. contorta/Arctostaphylos uva-ursi* habitat type is at least 25 cm (10 inches) annually. Much of the precipitation falls as snow. Streamflow can be substantially increased by clearcutting about one-third of the area in small patches interspersed with uncut timber.

Figure 16.—In this old stand dominated by *Pinus contorta*, the only tree reproduction is occurring on a mound of mineral soil exposed at the base of a wind-thrown tree. On the mound near the meter stick are 15 *P. contorta* seedlings.

Figure 17.—*Pinus contorta* was clearcut from this block on Caribou Mesa in 1967 (photograph was taken in 1973). Some *P. contorta* regeneration is occurring but most of the seedlings are hidden under a relatively dense cover of heliophytes. Best *Pinus* regeneration can be seen in right background.

Pinus contorta/Vaccinium scoparium

Description.—The *Pinus contorta/Vaccinium scoparium* habitat type also occurs primarily in the central third of the Bighorn Mountains on granitic soils, but on more mesic habitats than the *P. contorta/Arctostaphylos uva-ursi* habitat type. *P. contorta* is the only tree species in the overstory. Not all of the 11 stands sampled in this habitat type had abundant reproduction, but *P. contorta* is the only successfully reproducing tree species.

The understory vegetation is variable; *Vaccinium scoparium* is the dominant species (fig. 18). Other species that are more frequent and constant than in the *P. contorta/Arctostaphylos uva-ursi* habitat type are *Festuca ovina, Poa interior, P. nervosa, Trisetum spicatum, Antennaria rosea, Arnica cordifolia, Epilobium angustifolium,* and *Rosa acicularis.*

A *Pinus contorta/Vaccinium scoparium* community type described by Pfister and others (1974) in Montana shares with the *P. contorta/Vaccinium scoparium* and *P. contorta/Arctostaphylos uva-ursi* habitat types in the Bighorns such conspicuous species as *Juniperus communis, Arnica cordifolia,* and *Epilobium angustifolium.* In the Wind River Mountains, Reed (1969) recognized two community types dominated by *Pinus contorta,* but he considered these seral to habitat types dominated by *Abies lasiocarpa* or *Picea engelmannii.*

Management Implications.—Wildfires have been less severe in this habitat type than in the *P. contorta/Arctostaphylos uva-ursi* habitat type. Site indexes and timber productivity are the highest in the *P. contorta* series. Even-aged management under either a clearcutting or shelterwood cutting alternative is recommended for most stands (Alexander 1974). A shelterwood system has the advantages of meeting wildlife cover and visual management requirements while at the same time providing shade needed to conserve soil moisture and control overstocking. It also provides some control over dwarf mistletoe, although clearcutting is a more effective silvicultural control. Uneven-aged management under individual tree or group selection cutting can reduce stand susceptibility to mountain pine beetles by removing the most susceptible host trees. Growth will be substantially reduced, however. Treatment of stands in relation to cone serotiny is the same as in the *P. contorta/Arctostaphylos uva-ursi* habitat type.

Poletimber stands in this habitat type have better spacing and crown class differentiation. Thinning to a basal area level of 80 is most appropriate for individual tree and stand growth.

The *P. contorta/Vaccinium scoparium* habitat type is summer range for wildlife. Forage production is the best in the *Pinus contorta* series for both livestock and big game, and can substantially increase for short periods of time following clearcutting. Clearcutting in small patches or strips will provide more increase in the 25 to 30 cm (10 to 12 inches) of natural runoff than either shelterwood or group selection cutting (Leaf 1975, Leaf and Alexander 1975).

Figure 18.—*Pinus contorta/Vaccinium scoparium* habitat type. **A.** At this site, all size classes of *Pinus* are represented. **B.** At this site, *Pinus* is present in only three d.b.h. classes. There is no evidence of encroachment at either site by other conifer species.

Picea engelmannii Series

This series includes those forests in the Bighorn Mountains where *Picea engelmannii* replaces *Pinus contorta* as the climax dominant. These forests overlap the *P. contorta* series, but occur on more mesic habitats. *P. contorta* remains an important seral species in *P. engelmannii* forests, however. Stands in this series are located primarily in the central third of the Bighorns. On the west side of the mountains, *Picea*-dominated forests extend down to the shrub-steppe vegetation on the more favorable habitats.

All *Picea* in the Bighorns is referred to as *P. engelmannii;* however, it has been demonstrated that the species has hybridized and introgressed with *P. glauca* (Daubenmire 1974). In Montana, Pfister and others (1974) reported widespread hybridization, and suggested that these hybrid populations might better be adapted to occupy habitats below the limits for *Abies lasiocarpa.*

This series is represented by 10 plots and one habitat type (table 1). The stands sampled fall into three general age categories; 60-70 years old, 130-150 years old and 220 to 265 years old. All ages were measured at breast height. (The population data and undergrowth data for *Picea engelmannii* stands are recorded in appendix tables 3 and 8 respectively.)

Picea engelmannii/Vaccinium scoparium

Description.—The *Picea engelmannii/Vaccinium scoparium* habitat type occurs mostly on granitic soils, although it may also occur on limestone and glacial moraines (fig. 19). It is usually found on level topography or on northwest- to north-facing slopes at the same elevations where the *Pinus contorta/Vaccinium scoparium* habitat type occurs on the warmer slopes. *Pinus contorta* is the most common seral species in the overstory of the *P. engelmannii/Vaccinium scoparium* habitat type, making up 10 to 68 m²/ha (44 to 296 ft²/acre) of the basal area. *Picea engelmannii* may be less abundant in the overstory, but the abundance of *Picea* reproduction and the presence of a continuing seed source indicates a succession toward *Picea* dominance in the overstory. A few *Abies lasiocarpa* trees can be found in these stands, but reproduction is poor, and there is no clear evidence that *Abies* will ever be dominant.

Following disturbance in this habitat type, both *Pinus contorta* and *Picea engelmannii* establish simultaneously, but *P. contorta* seedlings usually outnumber those of *P. engelmannii. P. contorta* may remain the dominant overstory species for 200 years or more.

The understory in this habitat type is dominated by *Vaccinium scoparium,* with an average coverage of more than 40 percent. Other important species include *Juniperus communis, Antennaria racemosa, Arnica cordifolia, Epilobium angustifolium, Fragaria virginiana, Lupinus argenteus, Rosa acicularis, Senecio streptanthifolius,* and *Poa nervosa.* Most understory species are shared with the *P. contorta/Vaccinium scoparium* habitat type, but a few indicator species are found exclusively in each habitat type. For example, *Antennaria racemosa* and *Fragaria virginiana* are characteristic of the *Picea engelmannii/Vaccinium scoparium* habitat type, while *Antennaria rosea, Poa interior,* and *Trisetum spicatum* are characteristic of the *Pinus contorta/Vaccinium scoparium* habitat type.

Figure 19.—*Picea engelmannii/Vaccinium scoparium* habitat type occurring here on limestone derived soil. In this climax stand, most size classes of *Picea* are represented. There is a sizeable clump of *Juniperus communis* in the center of the photo.

Reed (1969) described a *Picea engelmannii/Vaccinium scoparium* habitat type in the Wind River Mountains in which *Picea* was dominant but *Abies lasiocarpa* was also present and reproducing in some stands. This habitat type has few species in common with its counterpart habitat type in the Bighorns. In Montana, there is no direct counterpart to this habitat type, but Pfister and others (1974) describe several *P. engelmannii*-dominated habitat types in which *Vaccinium scoparium* is an understory species. In the Black Hills there is no *Picea engelmannii,* but a *Picea glauca/Vaccinium scoparium* habitat type has been described which occupies very mesic habitats on both limestone and granitic soils (Thilenius 1971).

Management Implications.—Timber productivity varies considerably (Alexander 1967). Understory vegetation changes slowly after major disturbance, and competition is not severe between tree seedlings and understory vegetation. There may be a manageable stand of advanced reproduction in much of this habitat type. While most silvicultural systems can be used (Alexander 1974), removal of the mature overstory in these mixed stands is likely to result in an even-aged replacement stand of seral *Pinus contorta* unless extreme care is taken in logging to protect advanced *Picea engelmannii.* In mixed stands where *P. contorta* makes up a large part of the overstory, a shelterwood system that removes most of the *P. contorta* in the first cut can be used to maintain or increase the proportion of *P. engelmannii* in the stand. Clearcutting is more likely to eliminate *P. engelmannii* on southerly exposures than on other aspects. Where protection from direct solar radiation and excessive soil moisture losses is necessary for survival of *P. engelmannii* seedlings, shelterwood is the only appropriate even-aged system. Uneven-aged management with group selection or individual-tree selection cutting can be used in mixed-age stands. Group selection is likely to perpetuate the existing species mix, while individual tree selection will favor *P. engelmannii,* especially if the initial cutting removes a large proportion of *P. contorta.*

The *Picea engelmannii/Vaccinium scoparium* habitat type is not heavily used by livestock, but is big game summer range. It occupies some of the highest water-yielding areas (up to 38 cm (15 inches) of natural runoff annually) in the Bighorn Mountains. Small patch or strip clearcuts results in greater forage production for big game animals and larger increases in water available for streamflow than either shelterwood, group selection, or individual-tree selection cutting (Wallmo 1969, Leaf 1975). New openings must be cut periodically to maintain these increases.

Abies lasiocarpa Series

This series, represented by 34 plots, occupies the highest coniferous forest zone in the Bighorn Mountains (see table 1). These forests—dominated by *Abies lasiocarpa* and *Picea engelmannii*—are usually referred to as subalpine, but both species can extend to low elevations under suitable moisture-temperature regimes.

The habitat types described in this series are all named for *Abies lasiocarpa* as the climax dominant to be consistent with common usage (Daubenmire and Daubenmire 1968). In the Bighorns, *Picea engelmannii* is a coclimax dominant, with little evidence that it will ever be completely replaced by *A. lasiocarpa.* Young *A. lasiocarpa* usually outnumber the young *P. engelmannii* because *A. lasiocarpa* reproduces largely by layering, whereas *P. engelmannii* reproduces only from seed. In most stands, *Pinus contorta* is present as a seral species, and in a few stands it appears to be self-perpetuating.

Following disturbance, both *A. lasiocarpa* and *P. engelmannii* can reestablish immediately with or without *P. contorta,* depending on the type of disturbance and availability of seed. *P. contorta* is a less-vigorous invader of habitats on limestone soils than on those of granitic origin.

Three habitat types are recognized in this series. Stands sampled ranged from 90 to 410 years old at breast height. Basal areas of *A. lasiocarpa* never exceeded 30 m²/ha (131 ft²/acre). *P. contorta* is more likely to occur in stands less than 200 years old, but its basal area never exceeded 50 m²/ha (218 ft²/acre), regardless of age. The maximum basal area of *P. engelmannii* in stands younger than 200 years was 30 m²/ha; but in stands older than 200 years, it was 74 m²/ha (322 ft²/acre) (fig. 20). (Tree population data and undergrowth data for *Abies lasiocarpa* stands are recorded in the appendix, tables 3 and 8 respectively.)

Abies lasiocarpa/Vaccinium scoparium

Description.—This habitat type, represented by 25 stands, is recognized by the almost constant presence and reproductive success of *Abies lasiocarpa* and by the abundance and understory dominance of *Vaccinium scoparium* (fig. 21). *Picea engelmannii* is present as a self-reproducing coclimax species.

The overstory is dominated by *A. lasiocarpa* and *P. engelmannii.* *Pinus contorta* is an important seral species (fig. 22); *Pseudotsuga menziesii* is an occasional minor seral species. Ground cover of *Vaccinium scoparium* varies from nearly 100 percent to as low as 10 percent. Other understory species with

Figure 20.—Basal areas of important tree species in *Abies lasiocarpa*-dominated habitat types. Data show relationships among stand age and numbers of stands in which species occur. (Solid bars are *A. lasiocarpa*, open bars are *P. engelmannii,* and hatched bars are *P. contorta*.)
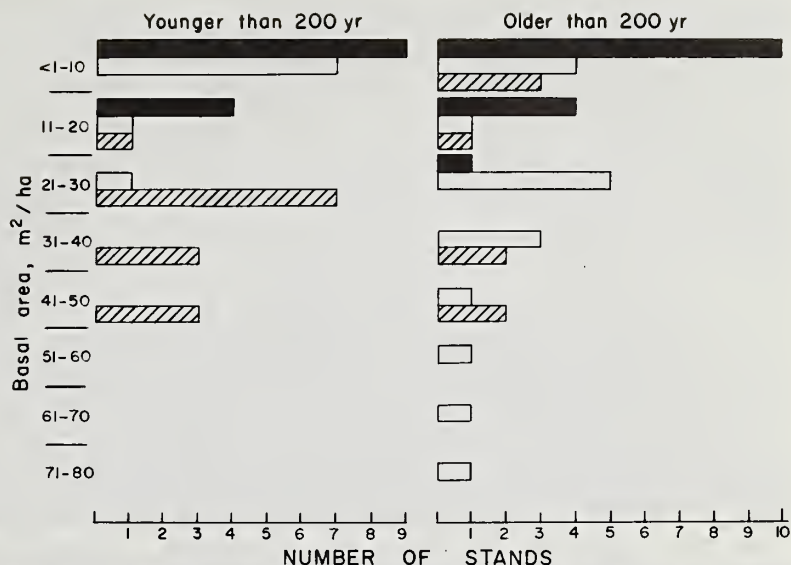
Figure 21.—*Abies lasiocarpa/Vaccinium scoparium* habitat type. **Left.** One of the most mature stands studied, there is no *Pinus contorta* present. **Right.** Ground cover of unusually dense *Vaccinium scoparium* which is slightly higher than 1 dm.

Figure 22.—*Abies lasiocarpa/Vaccinium scoparium* habitat type. This is an old seral stand in which most of the large trees are nonreproducing *Pinus contorta*. The reproducing trees are *Picea engelmannii* and *Abies lasiocarpa*. Ground cover is typical *Vaccinium scoparium* union.

high constancy are *Poa nervosa, Antennaria racemosa, Arnica cordifolia, Epilobium angustifolium, Lupinus argenteus, Fragaria virginiana, Potentilla diversifolia,* and *Pyrola secunda.*

The *Abies lasiocarpa/Vaccinium scoparium* habitat type, or others very similar to it, occur throughout a large region of the Rocky Mountains. In Montana, it constitutes most of the highest elevation forested zone east of the Continental Divide (Pfister and others 1974).

Management Implications.—This habitat type is quite similar in management implications to the *Picea engelmannii/Vaccinium scoparium* habitat type in the Bighorns, and the two can be treated in the same manner. There is one important difference however, the presence of *A. lasiocarpa* in the understory. Any silvicultural system that depends on advanced reproduction or reproduction establishing under a partial overstory following cutting, will have a high proportion of *A. lasiocarpa* in the replacement stand.

Abies lasiocarpa/Shepherdia canadensis

Description.—The *Abies lasiocarpa/Shepherdia canadensis* habitat type, represented by two stands, is limited to north slopes along the west side of the Bighorn Mountains. This habitat type may be a phase of the *A. lasiocarpa/Vaccinium scoparium* habitat type, but the abundance of *Shepherdia canadensis* is a very distinctive characteristic, thus for the present the vegetation is categorized at the habitat type level (fig. 23).

The overstory is dominated by the self-producing species *A. lasiocarpa* and *Picea engelmannii. Pinus contorta* is an important seral species and *Pseudotsuga menziesii* a minor seral species. In addition to *Shepherdia canadensis, Vaccinium scoparium* is well represented in the understory. Other important understory species include *Juniperus communis, Berberis repens, Linnaea borealis, Spiraea betulifolia, Rosa acicularis, Pyrola secunda,* and *Arnica cordifolia.*

There is apparently no counterpart to this habitat type in the Medicine Bow Mountains (Wirsing and Alexander 1975), Wind River Mountains (Reed 1969) or in Montana (Pfister and others 1974).

Management Implications.—The management implications for this habitat type are similar to the *Picea engelmannii/Vaccinium scoparium* habitat type, and the two can generally be handled in the same manner. However, timber productivity may be

lower and competition more severe between tree seedlings and understory vegetation in this habitat type.

Abies lasiocarpa/Arnica cordifolia

Description.—This habitat type occurs on shale-derived soils and represents some of the oldest forests dominated by *Abies-Picea* in the Bighorn Mountains. The significant diagnostic characteristics of the seven stands representing this habitat type are the self-reproducing population of *Abies lasiocarpa* and *Picea engelmannii,* the constant occurrence of *Arnica cordifolia,* and the virtual absence of *Vaccinium scoparium* (fig. 24).

The overstory is dominated by *A. lasiocarpa* and *P. engelmannii.* In some stands, the latter species is present in substantial numbers in only the larger diameter classes. Seral trees in this habitat type include *Pinus contorta* and *Pseudotsuga menziesii,* but they do not occur in all stands. The understory may be sparse. In addition to *Arnica cordifolia,* four or more of the stands sampled also contained *Ribes lacustre, Poa nervosa, Antennaria racemosa, Allium brevistylum, Arnica latifolia, Epilobium angustifolium, Fragaria virginiana, Galium boreale, Lupinus argenteus, Moneses uniflora, Pyrola secunda* and *Thalictrum occidentale.*

The only other *Abies lasiocarpa/Arnica cordifolia* habitat type reported occurs in Montana (Pfister and others 1974). In addition to *Arnica cordifolia,* species occurring in at least 50 percent of the stands in both Montana and in the Bighorns are *Fragaria virginiana, Pyrola secunda,* and *Thalictrum occidentale.*

Management Implications.—Understory vegetation does not compete severely with tree seedlings after cutting. Timber productivity may be lower in this habitat type than in the *Abies lasiocarpa/Vaccinium scoparium* habitat type. Even- and uneven-aged silvicultural systems—which benefit timber and water production, and recreation and esthetics—suggested for the *Picea engelmannii/Vaccinium scoparium* habitat type are applicable here. Management with advanced reproduction is likely to result in a replacement stand predominantly of *Abies lasiocarpa,* however, In older stands, some treatment of down material is necessary for future management. Younger stands provide some forage for livestock and big game, but older stands are used primarily for bedding grounds. The potential for increasing forage production by harvesting timber is not great in this habitat type.

Figure 23.—*Abies lasiocarpa/Shepherdia canadensis* habitat type. *Pinus contorta* is an important seral species in this stand. The ground cover is dominated by *Shepherdia canadensis,* which grows to about 7 dm. Under the *Shepherdia* and apparent in the foreground is *Vaccinium scoparium.*

Figure 24.—*Abies lasiocarpa/Arnica cordifolia* habitat type. **A.** In this photograph, taken at the edge of the stand, most size classes of *Picea engelmannii* and *Abies lasiocarpa* are present. *Pinus contorta* however is present only in larger size classes. **B.** The *Arnica cordifolia* union shares numerous species with the *Vaccinium scoparium* union, except for *Vaccinium* which is absent or very rare in the *Arnica* union. Shown here are *A. cordifolia, A. latifolia, Thalictrum occidentale, Lupinus* spp., *Allium brevistylum, Galium boreale* and *Pyrola secunda.* Mosses and lichens form a conspicuous carpet over the dead organic matter on the forest floor.

21

KEY TO THE FOREST HABITAT TYPES OF THE BIGHORN MOUNTAINS

1. Conifers absent or rare, not reproducing; dominant tree species is *Populus tremuloides* .... *POPULUS TREMULOIDES/LUPINUS ARGENTEUS*

1. Conifers present and reproducing in the habitat

   2. *Pinus ponderosa* present; other conifers absent

      3. Undergrowth dominated by herbaceous species; grasses particularly important

         4. *Agropyron spicatum* dominant in the undergrowth; *Balsamorhiza sagittata* also conspicuous .... *PINUS PONDEROSA/AGROPYRON SPICATUM*

         4. *Festuca idahoensis* dominant in the undergrowth; habitat somewhat more mesic than above .... *PINUS PONDEROSA/FESTUCA IDAHOENSIS*

      3. Undergrowth dominated by shrubby species

         5. *Juniperus communis* dominant in the undergrowth; *Spiraea betulifolia, Symphoricarpos albus,* and *Berberis repens* may also be conspicuous .... *PINUS PONDEROSA/JUNIPERUS COMMUNIS*

         5. *Juniperus communis* absent or rare in the undergrowth

            6. *Spiraea betulifolia* dominant in the undergrowth; *Symphoricarpos albus* and *Berberis repens* may also be conspicuous. *Physocarpus monogynus* absent or rare ... *PINUS PONDEROSA/SPIRAEA BETULIFOLIA*

            6. *Physocarpus monogynus* dominant in the undergrowth .... *PINUS PONDEROSA/ PHYSOCARPUS MONOGYNUS*

   2. Coniferous trees other than *Pinus ponderosa* present and reproducing

      7. *Pinus contorta, Picea engelmannii,* and *Abies lasiocarpa* absent or at least not reproducing; *Pseudotsuga menziesii* reproducing satisfactorily

         8. *Physocarpus monogynus* dominant in the undergrowth .... *PSEUDOTSUGA MENZIESII/PHYSOCARPUS MONOGYNUS*

         8. *Physocarpus monogynus* absent or rare in the undergrowth

            9. *Juniperus communis* dominant in the undergrowth; *Berberis repens* not abundant, may be absent; undergrowth generally sparse .... *PSEUDOTSUGA MENZIESII/BERBERIS REPENS JUNIPERUS COMMUNIS* PHASE

            9. *Juniperus communis* present or absent in the undergrowth; not dominant; *Berberis repens* dominant in the undergrowth .... *PSEUDOTSUGA MENZIESII/BERBERIS REPENS*

   7. *Pinus contorta, Picea engelmannii,* or *Abies lasiocarpa* present. *Pseudotsuga menziesii* may be present but not reproducing satisfactorily

      10. *Pinus contorta* reproducing; no evidence of invasion by *Picea engelmannii, Abies lasiocarpa,* or *Pseudotsuga menziesii*

         11. Undergrowth dominated by *Arctostaphylos uva-ursi; Vaccinium scoparium* absent or rare .... *PINUS CONTORTA/ ARCTOSTAPHYLOS UVA-URSI*

         11. Undergrowth dominated by *Vaccinium scoparium; Arctostaphylos uva-ursi* absent or rare .... *PINUS CONTORTA/VACCINIUM SCOPARIUM*

      10. *Picea engelmannii* and/or *Abies lasiocarpa* dominant and reproducing; *Pinus contorta* and/or *Pseudotsuga menziesii* may be present but reproducing insufficiently to maintain population

         12. *Abies lasiocarpa* absent; *Picea engelmannii* dominant. Undergrowth dominated by *Vaccinium scoparium* ...... *PICEA ENGELMANNII/VACCINIUM SCOPARIUM*

12. Both *Picea engelmannii* and *Abies lasiocarpa* dominant

13. Undergrowth dominated by *Shepherdia canadensis* ......
ABIES LASIOCARPA/SHEP-HERDIA CANADENSIS

13. *Shepherdia canadensis* absent or rare, not dominant in the undergrowth

14. Undergrowth dominated by *Vaccinium scoparium* .
.... ABIES LASIOCARPA / VAC-CINIUM SCOPARIUM

14. Undergrowth dominated by *Arnica cordifolia; Vaccinium scoparium* absent or rare ....
ABIES LASIOCARPA/ARNICA CORDIFOLIA

The distribution and successional status of tree species in relation to habitat type are shown in figure 25.

Habitat type / Species	Pinus ponderosa	Pseudotsuga menziesii	Pinus flexilis	Populus tremuloides	Pinus contorta	Picea engelmannii	Abies lasiocarpa
Pinus ponderosa/Agropyron spicatum	C						
Pinus ponderosa/Festuca idahoensis	C						
Pinus ponderosa/Juniperus communis	C						
Pinus ponderosa/Spiraea betulifolia	C						
Pinus ponderosa/Physocarpus monogynus	C						
Pseudotsuga menziesii/Berberis repens, Juniperus communis phase	S	C	s				
Pseudotsuga menziesii/Berberis repens	s	C	s		s		
Pseudotsuga menziesii/Physocarpus monogynus	S	C	s		s		
Populus tremuloides/Lupinus argenteus				C			
Pinus contorta/Arctostaphylos uva-ursi					C		
Pinus contorta/Vaccinium scoparium		s			C		
Picea engelmannii/Vaccinium scoparium		s			S	C	
Abies lasiocarpa/Shepherdia canadensis		s			S	C	C
Abies lasiocarpa/Vaccinium scoparium		s			S	C	C
Abies lasiocarpa/Arnica cordifolia		s			S	C	C

C = major climax species, s = seral, S = seral in some stands.

Figure 25.—Distribution of tree species through habitat types, showing dynamic status.

23

DISCUSSION

Habitat Type Classification

A habitat type classification of forest lands is considered a natural classification in that vegetation dynamics and their expressions are recognized and described. The classification also is an initial assessment of pertinent ecosystem characteristics, and provides the framework in which to relate other ecosystem studies.

Vegetation is utilized as the principal component of the classification scheme because it is convenient to recognize habitat types by their climax, or potentially climax, vegetation. Within the classification system, additional studies may relate to tree growth, to the possibility of predicting disease and insect susceptibility, to recognizing suitable browse production areas following disturbance, and to correlations between vegetation and soil factors (Daubenmire 1961, Roe 1967).

Identifying habitat types also allows mapping of recognizable land units which have significant similarities and/or dissimilarities. It has been argued that variation in vegetation is continuous to the extent that boundaries can only be defined arbitrarily. There is sufficient evidence to suggest, however, that an ecologic approach which distinguishes seral from climax species, recognizes self-perpetuating populations, recognizes that not all species are of equal ecologic importance, and attempts to relate abiotic factors with biotic factors will also recognize significant discontinuities in the vegetational gradients. Maps which result from intensive study of habitat types are permanent; they reflect the potential of the land units. If needed, suitable symbols can be utilized to indicate the nature of the current standing crops of vegetation on given habitat types. Classifying and mapping large blocks of natural forests into manageable units presents insurmountable problems if the discontinuities of the vegetation are not considered.

Finally, the habitat type approach utilizes indicator species to signify possible important ecosystem differences. For example, the presence or absence of significant quantities of *Arctostaphylos uva-ursi* in *Pinus contorta* forests in the Bighorns is of prime ecologic importance that can be attributed to soil moisture differences. In high-elevation *Abies lasiocarpa/Picea engelmannii* forests, the absence of *Vaccinium scoparium* is of singular importance, and is correlated with several soil characteristics.

Biotic Succession

A fundamental concept in ecology is that of biotic succession—changes in population structure of species with time that continue until change is imperceptible. Populations are then in an apparent steady state with their environment, and the biotic community is referred to as climax.

When disturbed, all forest vegetation in the Bighorns can redevelop along various lines of succession. Climax vegetation can reestablish directly on sites previously occupied, or it can be replaced temporarily, sometimes for several hundred years, by seral communities. *Pinus ponderosa* and *Pseudotsuga menziesii* invade the upslope or into more mesic sites following disturbance. *Picea engelmannii* and *Abies lasiocarpa,* on the other hand, exhibit no strong tendency to move downslope or into more xeric sites following disturbance (fig. 25). *Pinus contorta* is the only tree species in the Bighorns which moves both upslope and downslope following disturbance (fig. 25).

Pinus contorta is the most abundant tree in the Bighorns, but much about its ecology is inadequately understood. Most stands of *P. contorta* originated following fire, and some persist as extremely dense, even-aged stands. Not all stands of *P. contorta* are seral or subclimax, however. In some, the population structure is that of a self-reproducing species, and there is little evidence of replacement by *Picea engelmannii* or *Abies lasiocarpa*. There are some clearcut areas in the Bighorns where *P. contorta* is not invading even though causes of failure to reestablish are not apparent. Lack of successful regeneration on these sites underscores the need for a better understanding of the forest ecology of the Bighorns.

Distributional Relationships of Trees in the Bighorns

The distribution of forest trees in the Bighorns is shown along an elevational (temperature-moisture) gradient in figure 26. Along this gradient, each species is climax for only the portion shown in heavy lines. *Abies lasiocarpa* is the only species that is climax over its entire elevational range. *Pinus flexilis,* on the other hand, is always seral to either *Pinus ponderosa* or *Pseudotsuga menziesii*. *P. menziesii* and *Pinus contorta* occupy relatively large elevational ranges in the Bighorns, but are climax over only a limited portion. Because most tree species occupy a relatively broad elevational range, it is important to recognize habitat types at the elevational range where each tree is the most effective competitor, and produces stable populations.

Species Richness

The median number of species per 125 m² sample for each habitat type is shown in table 2. In contrast
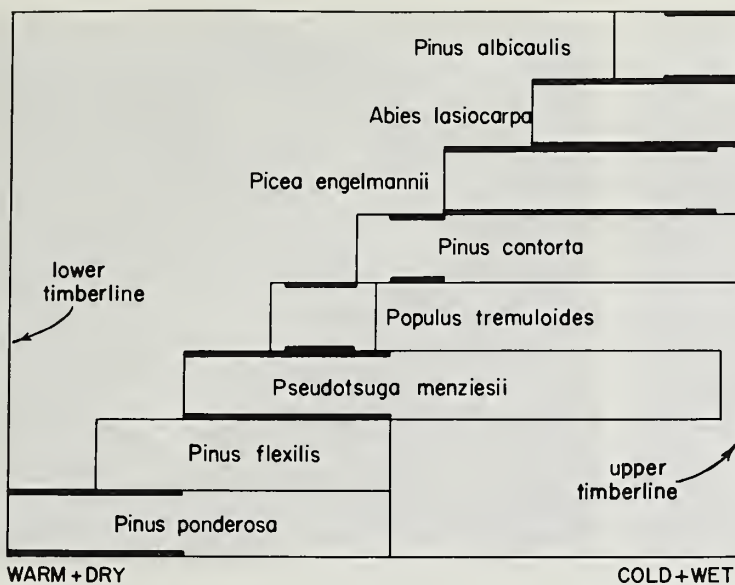
Figure 26.—Tree distributions in the Bighorn Mountains. Horizontal bars represent relative extent of tree distributions along climatic gradient. Heavy lines indicate that portion of the gradient where each species is climax.

Table 2. Species richness of the ground cover in habitat types of the Bighorn Mountains

Habitat type	Median number[1] of undergrowth species	Number of stands studied
Pinus ponderosa/ Agropyron spicatum	20	1
Pinus ponderosa/ Festuca idahoensis	25	2
Pinus ponderosa/ Juniperus communis	18	1
Pinus ponderosa/ Spiraea betulifolia	26	2
Pinus ponderosa/ Physocarpus monogynus	27	4
Pseudotsuga menziesii/ Berberis repens, Juniperus communis phase	22	2
Pseudotsuga menziesii/ Berberis repens	19	8
Pseudotsuga menziesii/ Physocarpus monogynus	25	3
Populus tremuloides/ Lupinus argenteus	24	4
Pinus contorta/ Arctostaphylos uva-ursi	18	5
Pinus contorta/ Vaccinium scoparium	20	11
Picea engelmannii/ Vaccinium scoparium	18	11
Abies lasiocarpa/ Shepherdia canadensis	25	2
Abies lasiocarpa/ Vaccinium scoparium	25	25
Abies lasiocarpa/ Arnica cordifolia	26	7

[1]Based on 125 m² per stand.

to the Wind River Mountains (Reed 1969), ground cover in habitat types of the Bighorns does not decrease in species richness as elevation increases. There is one peak in the low-elevation *Pinus ponderosa/Physocarpus monogynus* habitat type, and another in the high-elevation *Abies lasiocarpa/ Arnica cordifolia* habitat type. Habitat types with the fewest understory species occur more often on granitic soils. An exception is the *Pseudotsuga menziesii/Berberis repens* habitat type found on both granitic and sedimentary soils. Tree species richness is relatively simple in the Bighorns. The most tree species (four) occur in the *Pseudotsuga menziesii* habitat type at intermediate elevations, and in *Abies lasiocarpa* habitat types at high elevations.

Long-term Vegetational Changes in the Bighorns

The only way to document long-term vegetational changes is to compare quantitative records of existing vegetation with similar past records. Unfortunately, quantitative vegetational data were seldom obtained in early assessments of the forests in the Bighorns. Photographs can be useful in this respect, however. Gross changes in the vegetation at one location are apparent when photographs taken by Darton (1906) and again in 1973 were compared (figs. 27, 28). During the years since Darton's work, fewer fires occurred, and they burned over much smaller areas. As a result, present forests have a more closed appearance.

Figure 27.—East side of the Bighorns along Highway 14. **Left.** Photograph taken between 1901 and 1905 by N. H. Darton. Note sparse vegetation either side of massive limestone outcrop. (Photo courtesy of U.S. Geol. Survey.) **Right.** Same location photographed in 1973. Succession has filled in most of the area with *Pinus contorta* and *Picea engelmannii*.

Figure 28.—Near the bottom of Tensleep Canyon along Highway 16. **Above.** Photograph taken between 1901 and 1905 by N. H. Darton. Note sparse vegetation along canyon slope. (Photo courtesy of U.S. Geol. Survey.) **Right.** Same location photographed in 1973. Succession here is very slow, though a few more trees now occupy the slope of the canyon. Some trees in the original Darton photo are still present.

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APPENDIX

Table 3. Tree population structures for each habitat type. Numbers of trees listed are based on sample plot data of 375 m² per stand. Species having a coverage of less than 0.1% are indicated by +.

Habitat type and species	No. of stands sampled	Mean basal area	Diameter (at breast height) classes in dm								
			0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8
		m²/ha	— — — — — — — — — — No. trees — — — — — — — — — —								
HT Pinus ponderosa - Agropyron spicatum	1										
Pinus ponderosa		27.8	3	.	10	.	.	.	1	.	.
HT Pinus ponderosa - Festuca idahoensis	2										
Pinus ponderosa		33.1	1	9	7	6	3	.	.	1	1
HT Pinus ponderosa - Juniperus communis	1										
Pinus ponderosa		62.0	8	12	6	4	8	1	1	1	.
HT Pinus ponderosa - Spiraea betulifolia	2										
Pinus ponderosa		32.2	.	1	4	4	7	1	.	.	.
HT Pinus ponderosa - Physocarpus monogynus	4										
Pinus ponderosa		.	1	14	15	14	3	+	.	+	.
Pinus flexilis		.	+	.	.	.	.	.	.	.	.
Pseudotsuga menziesii		.	+	.	.	.	.	.	.	.	.
HT Pseudotsuga menziesii - Berberis repens Juniperus communis phase	2										
Pseudotsuga menziesii		39.1	112	4	2	4	2	+	.	.	.
Pinus ponderosa		.	5	2	2	2	2	1	.	.	.
Pinus contorta		.	3	+	+	+	.	.	.	.	.
Picea engelmannii		.	.	.	+	.	.	.	.	.	.
HT Pseudotsuga menziesii - Berberis repens	8										
Pseudotsuga menziesii		57.9	669	9	10	12	5	2	+	+	+
Pinus contorta		.	+	.	+	+	+	.	+	.	.
Pinus flexilis		.	+	+	+	+	+	.	.	.	.
Picea engelmannii		.	+	.	.	+	.	.	.	.	.
HT Pseudotsuga menziesii - Physocarpus monogynus	3										
Pseudotsuga menziesii		26.4	260	7	5	3	2	.	.	.	.
Pinus ponderosa		.	8	13	15	4	2	.	.	.	.
Pinus flexilis		.	4	2	.	.	.	.	.	.	.
HT Populus tremuloides - Lupinus argenteus	4										
Populus tremuloides		38.4	926	35	55	7	.	.	.	.	.
Picea engelmannii		.	4	.	.	.	.	.	.	.	.
HT Pinus contorta - Arctostaphylos uva-ursi	5										
Pinus contorta		30.7	84	15	20	7	3	1	.	.	.
HT Pinus contorta - Vaccinium scoparium	11										
Pinus contorta		38.1	77	5	14	12	4	1	+	.	+
Picea engelmannii		.	+	+	.	+	.	.	.	.	.
Pseudotsuga menziesii		.	+	+	+	.	.	.	.	.	.
HT Picea engelmannii - Vaccinium scoparium	11										
Picea engelmannii		42.5	32	2	1	1	1	1	+	.	.
Pinus contorta		.	8	16	17	8	3	1	.	.	.
Pseudotsuga menziesii		.	1	+	+	.	.	.	.	.	.
Populus tremuloides		.	+	.	.	+	.	.	.	.	.
HT Abies lasiocarpa - Shepherdia canadensis	2										
Abies lasiocarpa		28.6	40	3	3	1	.	.	.	.	.
Picea engelmannii		.	15	2	1	+	.	.	.	.	.
Pinus contorta		.	45	2	10	10	2	+	.	.	.
Pseudotsuga menziesii		.	8	+	.	.	.	.	.	.	.
HT Abies lasiocarpa - Vaccinium scoparium	25										
Abies lasiocarpa		40.8	163	7	4	1	+	.	.	.	.
Picea engelmannii		.	43	2	2	1	1	+	+	+	+
Pinus contorta		.	23	3	5	7	4	1	+	.	.
Pseudotsuga menziesii		.	+	+	+	+	.	.	.	.	.
HT Abies lasiocarpa - Arnica cordifolia	7										
Abies lasiocarpa		60.8	488	24	7	2	+	.	.	.	.
Picea engelmannii		.	62	1	1	2	2	2	2	1	+
Pinus contorta		.	2	1	2	1	.	.	.	.	.
Pseudotsuga menziesii		.	5	+	.	+	.	.	.	.	.

Table 4. Undergrowth data of Pinus ponderosa dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but not in any microplot are indicated by *. Other data included are stand location and topographic position.

Stand Number	2	5	7	62	3	63	6	8	9	79
Location: Section	3	27	35	28	14	2	35	23	27	15
Township	50N	49N	57N	48N	53N	50N	57N	56N	54N	56N
Range	83W	83W	87W	83W	84W	83W	87W	87W	85W	87W
Topographic Position: Slope	30°	10°	25°	17°	28°	23°	23°	24°	15°	23°
Aspect	150°	355°	250°	195°	150°	25°	25°	395°	330°	320°
Elevation, meters	1829	1818	1311	2341	1798	1731	1402	1628	1804	1646
% Coverage / % Frequency (C/F)										
LARGE SHRUBS										
Acer glabrum	.	.	.	.	.	*	+	.30/2.0	.35/4.0	.
Amelanchier alnifolia	.	.	.	.	.	.	+	.	.	0.6/4.0
Juniperus communis	.	.	.	4.7/6.0	.	.	.	*	.	+
Physocarpus monogynus	.	.	1.8/12.	.	.	.	19./32.	44./76.	31./64.	79./100
Prunus virginiana	0.1/4.0	.	.	.	2.0/10.	.	1.2/8.0	.	0.3/2.0	.
Rhus trilobata	*	4.3/18.	.	.	.	*	.	.	.	.
Ribes cereum	+	.	.	.	.	.	.	.	.	.
Shepherdia canadensis	.	.	.	.	.	.	.	.	0.4/4.0	.
GRAMINOIDS										
Agropyron spicatum	5.3/38.	.	2.0/28.	.	.	.	*	.	.	.
Aristida longiseta	3.0/30.	.	.	.	.	.	.	.	.	.
Bromus tectorum	0.4/6.0	0.6/4.0	.85/10.	.	.	.	0.1/4.0	.	.	.
Carex filifolia	1.9/34.	1.4/36.	0.2/6.0	0.3/12.	.	.	.	.	.	.
Carex heliophila	.	.	.	.	.	0.3/12.	.	.	.	.
Carex xerantica	.	.	.	.	.	.	0.6/6.0	.	.	.
Elymus glaucus	.	.	.	.	.	.	.	.	.	+
Festuca idahoensis	0.3/2.0	6.7/52.	8.9/67.	.	.	0.4/4.0	0.4/8.0	0.4/6.0	.	0.8/14.
Hesperochloa kingii	.	1.2/8.0	1.2/10.	6.4/70.	0.3/4.0	1.0/10.	0.8/10.	.	1.3/22.	.
Koeleria cristata	1.3/12.	0.6/4.0	0.4/6.0	*	*	0.4/4.0	.	.	.	.
Poa interior	.	.	.	0.6/10.	.	0.6/26.	1.0/10.	0.4/6.0	0.4/2.0	0.4/6.0
Poa palustris	.	.	4.8/28.	.	0.4/8.0	.	5.4/40.	.	.	1.1/17.
Poa pratensis	+	+	0.5/10.	.	.	.	.	.	.	.
Stipa columbiana	.	.	.	.	.	.	.	.	+	.
Stipa comata	0.5/10.	+	.	.	.	.	.	.	.	.
Stipa viridula	.	.	1.2/16.	.	0.4/8.0	.	0.2/8.0	.	.	.
LOW SHRUBS AND HERBS										
Achillea millefolium	.	*	3.5/40.	0.2/2.0	0.4/4.0	0.3/4.0	1.5/38.	0.1/4.0	.	0.4/14.
Agoseris glauca	.	.	0.2/6.0	0.6/12.	.	+	.	.	.	0.3/12.
Allium cernuum	.	.	0.1/4.0	.	0.1/4.0	.	.	.	.	.
Allium textile	.	.	.	.	.	.	0.1/4.0	.	.	.
Anemone patens	0.8/4.0	.	2.2/10.	.	.	1.0/18.	0.8/12.	+	.	0.5/12.
Antennaria parviflora	.	.	0.7/2.0	.	.	.	.	.	.	.
Antennaria racemosa	.	0.1/4.0	.	*	.	.	0.3/2.0	.	.	.
Antennaria rosea	.	+	1.3/10.	.	.	1.1/12.	1.1/6.0	.	.	.
Arenaria congesta	.	.	.	.	.	0.1/8.0	.	.	.	.
Arnica cordifolia	.	.	.	+	.	+	.	21./88.	.	.
Arnica sororia	.	.	.	.	.	.	.	.	2.5/22.	.
Artemisia frigida	1.1/14.	0.8/12.	.	.	.	.	.	.	.	.
Aster conspicuus	.	.	.	.	.	.	0.2/6.0	.	.	.
Astragalus miser	.	.	.	.	.	.	.	.	.	2.2/20.
Astragalus succulentus	0.8/2.0	.	6.1/22.	3.3/22.	.	.	.	.	.	.
Balsamorhiza incana	.	.	.	.	.	.	.	.	*	0.4/14.
Balsamorhiza sagittata	0.2/8.0	8.2/24.	11./42.	.	2.3/24.	.	3.8/26.	.	.	.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage / % Frequency	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Besseya wyomingensis	.	.	.	.	.	0.1/2.0	.	.	.	.
Bupleurum americanum	.	.	.	.	.	.	.	.	.	0.2/4.0
Castilleja gracillima	.	1.6/24.	4.6/46.	.	0.2/8.0	.	2.0/28.	0.2/4.0	0.1/2.0	1.0/40.
Cerastium arvense	.	.	.	.	.	.	.	+	.	.
Clematis columbiana	.	.	.	.	.	.	.	+	+	.
Clematis tenuiloba	.	.	.	1.1/16.	2.5/14.	.	5.9/50.	0.6/6.0	.	1.9/36.
Corallorhiza striata	.	.	.	.	.	+	.	+	.	.
Crepis acuminata	0.1/4.0	.	+	.	.	.	.	.	0.3/2.0	.
Cystopteris fragilis	.	0.2/8.0	1.8/14.	.	.	0.4/4.0	.	1.7/38.	.	.
Delphinium bicolor	.	.	.	.	.	+	.	.	.	.
Disporum trachycarpum	.	.	.	.	.	.	+	.	+	+
Epilobium angustifolium	.	.	.	.	.	.	+	.	.	+
Erigeron divergens	.	.	.	.	.	.	.	1.0/8.0	.	.
Erigeron speciosus	0.1/4.0	.	*	.	.	.	0.1/4.0	.	0.3/2.0	0.6/24.
Erigeron subtrinervis	.	.	.	.	.	.	.	.	.	0.1/4.0
Eriogonum subalpinum	.	.	.	.	.	.	+	.	+	.
Erysimum argillosum	.	.	.	.	.	+	+	+	.	.
Erysimum asperum	.	0.6/4.0	+	.	.	.	+	+	.	.
Fragaria virginiana	0.2/4.0	.	.	0.3/12.	3.2/48.	0.2/8.0	0.4/4.0	1.7/16.	0.1/2.0	0.9/34.
Fritillaria atropurpurea	+	.	.	.	.	.	+	.	.	.
Galium aparine	.	.	0.3/12.	.	.	.	.	.	.	.
Galium boreale	.	.	.	.	+	+	+	+	+	.
Geranium viscosissimum	.	.	.	.	.	0.3/14.	.	.	+	.
Glycyrrhiza lepidota	+	.	.	0.2/8.0	.	.	.	.	.	.
Goodyera oblongifolia	.	.	.	.	.	.	.	.	+	.
Heuchera parviflora	0.6/14.	.	.	.	.	.	.	.	.	.
Hymenoxys acaulis	0.1/4.0	.	.	+	.	.	.	0.3/4.0	.	.
Lesquerella alpina	0.1/4.0	0.6/4.0	.	.	.	.	.	.	.	.
Leucocrinum montanum	0.1/4.0	.	.	.	.	.	.	.	.	.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage / % Frequency	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Lichens + Mosses	+	+	.65/12.	0.2/8.0	0.9/10.	1.1/16.	1.3/18.	1.3/22.	0.4/6.0	1.0/18.
Lithospermum incisum	+	.	.	.	.	.	.	.	.	.
Lomatium ambiguum	.	.	.	1.6/36.	0.4/6.0	.	.	.	0.1/4.0	0.7/36.
Lomatium dissectum	.	.	.	.	2.3/20.	.	.	.	.	.
Lupinus argenteus	.	.	.	.	+	.	.	.	.	+
Lycopodium obscurum	.	0.6/4.0	.	.	.	6.9/54.	3.4/20.	4.1/18.	.	.
Mahonia repens	.	0.3/12.	.	.	1.2/28.	.	.	5.9/30.	.	4.8/42.
Monarda fistulosa	.	.	.	.	.	.	+	.	.	.
Montia perfoliata	.	.	.	.	.	.	0.1/4.0	.	.	.
Musineon vaginatum	.	.	.	0.4/6.0	.	.	.	.	.	.
Opuntia polyacantha	0.4/6.0	.	.	.	.	.	.	.	.	.
Penstemon procera	.	.	.	.	+	.	.	+	.	.
Phlox multiflora	.	.	.	0.2/10.	.	.	.	.	.	.
Polygonum bistortoides	.	.	.	.	.	0.1/4.0	.	.	.	.
Potentilla diffusa	.	.	+	+	.	.	.	+	.	+
Potentilla fissa	.	.	.	.	.	1.1/16.	.	.	.	.
Rosa acicularis	.	0.6/4.0	+	.	+	0.2/6.0	.	+	.	1.5/10.
Sedum lanceolatum	+	.	+	.	+	.	.	.	.	.
Senecio streptanthifolius	.	.	.	.	.	+	.	0.1/10.	.	*
Smilacina racemosa	.	.	+	.	14./68.	.	.	.	0.4/6.0	0.8/14.
Spiraea betulifolia	.	8.6/52.	+	.	5.8/48.	5.3/38.	*	16./70.	14./56.	9.3/78.
Symphoricarpos albus	.	.	.	.	1.2/16.	18./90.	4.5/42.	4.5/42.	3.3/24.	11./80.
Taraxacum sp.	.	.	0.8/22.	.	.	0.4/6.0	.	.	.	.
Toxicodendron rydbergii	.	.	.	.	0.2/6.0	.	.	.	.	.
Viola nuttallii	0.6/14.	.	.	.	.	.	.	.	.	.
Yucca glauca	0.1/4.0	.	.	.	.	.	.	0.3/4.0	0.1/4.0	.
Zigadenus elegans	.	.	.	.	.	0.5/8.0	.	.	.	.

Table 5. Undergrowth data of Pseudotsuga menziesii dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but not in any microplot are indicated by *. Other data included are stand location and topographic position.

Part 1

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
Location: Section	33	19	28	30	24	18	26	11	13	25	12	22	22
Township	48N	48N	54N	56N	48N	48N	49N	49N	48N	49N	53N	56N	56N
Range	83W	83W	85W	92W	87W	86W	87W	87W	87W	87W	90W	87W	56W
Topographic Position: Slope	3°	5°	5°	5°	16°	23°	24°	26°	23°	15°	24°	20°	20°
Aspect	215°	75°	85°	179°	274°	255°	215°	205°	69°	180°	310°	50°	50°
Elevation, meters	2286	2365	2240	2256	2158	2207	2573	2591	2207	2609	1878	1981	2012
	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
LARGE SHRUBS													
Acer glabrum	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia tridentata	.	.	.	.	2.0/2.0	.	.	.	0.3/2.0	.	.	.	.
Ceanothus velutinus	.	.	.	.	.	.	.	.	+	+	.	.	.
Juniperus communis	+	48./37.	.	2.4/4.0	.	0.1/4.0	7.0/14.	13./34.	1.7/2.0	0.6/4.0	.	4.2/10.	5.1/14.
Juniperus osteosperma	.	.	.	+	.	.	.	.	.	+	.	.	.
Juniperus scopulorum	.	*	.	.	.	.	.	.	.	.	*	0.3/2.0	+
Physocarpus monogynus	.	.	.	.	.	.	.	.	.	.	28./100	25./72.	23./76.
Ribes cereum	.	+	.	.	.	.	.	.	.	.	.	.	.
Ribes lacustre	.	*	+	.	.	.	.	.	.	.	.	.	.
Ribes montigenum	.	.	.	.	0.1/4.0	0.8/6.0	0.8/4.0	1.1/6.0	0.3/4.0	0.4/8.0	.	.	.
Shepherdia canadensis	.	.	.	.	.	.	.	.	.	.	.	0.6/4.0	.
GRAMINOIDS													
Agropyron spicatum	.	.	.	.	.	.	.	.	0.4/8.0	.	.	.	.
Carex brevipes	.	.	.	.	.	0.2/6.0	.	.	0.1/2.0	.	.	.	.
Carex vallicola	.	.	.	.	.	.	+	.	+	.	.	.	.
Festuca idahoensis	0.3/10.	.	.	.	.	.	.	.	1.4/10.	.	.	.	.
Festuca ovina	0.5/10.	+	.	.	.	+	.	0.9/18.	1.8/20.	.	.	.	0.3/2.0
Hesperochloa kingii	1.7/18.	.	.	+	+	.	+	.	7.0/40.	.	.	.	.
Koeleria cristata	.	.	.	.	.	.	+	.	.	.	+	.	.

Part 2

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage / % Frequency	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Poa canbyi	.	.	.	.	.	.	.	.	0.1/2.0	.	+	.	.
Poa columbiana	.	.	.	.	+	.	.	.	.	.	.	.	.
Poa fendleriana	.	.	.	.	.	0.1/2.0	.	.	.	.	.	.	.
Poa interior	.	.	.	.	.	.	.	.	.	0.1/4.0	1.2/10.	.	+
Poa nervosa	0.4/6.0	0.2/8.0	0.6/26.	.	0.4/6.0	1.0/20.	0.4/14.	0.1/4.0	.	0.4/14.	.	.	0.1/4.0
Poa scabrella	.	+	.	.	.	1.7/10.	.	.	+	.	.	+	.
Stipa comata	+	.	.	.	.	.	.	.	0.5/5.0	.	.	.	.
Trisetum spicatum	.	.	.	.	.	.	.	.	.	.	.	.	0.6/12.
LOW SHRUBS AND HERBS													
Achillea millefolium	0.4/14.	+	0.1/4.0	.	.	.	.	0.7/8.0	.	.	+	0.1/4.0	.
Agoseris glauca	.	0.1/4.0	.	.	.	.	.	.	.	.	.	.	.
Allium cernuum	.	.	0.3/2.0	+	.	.	.	.	.	.	.	.	.
Anemone multifida	.	0.3/10.	+	.	.	.	0.1/4.0	+	.	.	.	0.5/20.	.
Antennaria parviflora	0.2/8.0	.	.	.	.	.	.	+	.	.	.	.	0.4/4.0
Antennaria racemosa	.	.	.	.	.	.	.	+	+	.	.	.	.
Antennaria rosea	+	0.3/2.0	.	.	.	.	+	.	+	.	+	.	.
Arabis nuttallii	.	.	.	.	.	.	+	+	.	.	.	.	.
Arctostaphylos uva-ursi	.	.	.	.	.	.	.	+	.	+	.	+	0.1/4.0
Arenaria congesta	0.4/8.0	.	.	.	.	.	.	0.3/4.0	+	.	.	0.1/4.0	.
Arnica cordifolia	.	0.9/24.	32./90.	.	5.7/62.	7.5/54.	6.6/56.	9.8/46.	0.2/8.0	35./94.	.	4.0/34.	0.5/20.
Aster foliaceous	.	+	.	.	+	+	+	.	.	+	+	.	.
Astragalus miser	12./36.	.	.	.	.	.	.	.	.	.	.	.	.
Balsamorhiza sagittata	.	.	.	.	.	.	.	0.4/6.0	0.2/8.0	.	.	3.2/12.	2.3/8.0

Table 5, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage / % Frequency	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Castilleja gracillima	.	.	.	.	.	.	.	.	.	.	.	+	+
Cerastium arvense	.	+	.	.	.	.	.	.	.	+	+	+	+
Clematis tenuiloba	.	0.4/4.0	.	.	+	.	.	0.2/6.0	.	.	.	1.2/16.	0.7/18.
Cystopteris fragilis	.	.	.	.	+	+	.	+	+	.	.	.	.
Disporum trachycarpum	.	.	1.0/10.	+	.	0.3/2.0	+	.	.	.	.	.	.
Erigeron sp.	.	+	.	.	+	.	+	.	.	.	+	.	+
Epilobium angustifolium	0.2/6.0	.	.	+	+	+	.	+	.	+	+	.	+
Erysimum asperum	.	.	+	.	.	.	.	.	.	.	.	.	.
Fragaria virginiana	.	0.4/14.	.	.	.	.	0.2/8.0	0.4/14.	.	.	.	.	.
Galium boreale	0.4/4.0	1.1/34.	6.8/80.	.	.	0.6/14.	0.6/12.	+	.	0.7/16.	.	0.6/22.	1.4/24.
Gentiana amarella	.	.	.	.	.	.	.	.	.	0.5/10.	.	.	+
Geranium viscosissimum	*	.	.	.	.	.	.	.	.	.	.	.	.
Geum triflorum	.	.	.	.	+	+	.	.	.	+	.	.	.
Glycyrrhiza lepidota	.	.	.	.	+	.	.	.	+	.	.	.	.
Hedysarum sulphurescens	0.3/2.0	.	.	.	.	.	.	.	.	.	.	0.4/4.0	+
Heuchera parviflora	.	.	.	.	0.1/4.0	.	0.1/4.0	0.1/4.0	0.1/4.0	1.0/10.	17./95.	.	.
Lichens + Mosses	2.0/30.	2.8/34.	0.1/5.0	0.1/4.0	0.4/6.0	0.8/20.	1.5/10.	.	0.1/4.0	.	.	0.5/8.0	1.4/16.
Lomatium dissectum	5.0/14.	.	+	.	.	.	.	.	.	.	.	0.3/12.	1.4/16.
Lupinus argenteus	.	.	.	.	.	.	.	.	.	0.5/10.	.	.	.
Lupinus monticola	.	.	.	.	.	.	6.1/50.	1.7/10.	.	.	.	.	.
Mahonia repens	.	.	.	12./72.	28./86.	11./50.	.	5.0/42.	2.0/12.	1.4/26.	1.3/20.	.	0.9/14.
Mertensia ciliata	.	1.2/20.	.	.	.	.	.	.	.	.	.	.	.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage / % Frequency	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Mitela pentandra	.	.	.	.	.	.	.	.	.	.	0.2/12.	.	.
Musineon vaginatum	.	.	.	.	.	.	.	.	.	.	.	.	+
Osmorhiza depauperata	.	5.4/46.	.	.	.	.	.	.	.	.	.	.	.
Penstemon aridis	.	.	.	.	.	.	.	0.6/4.0	.	.	.	.	.
Phlox multiflora	+	.	.	.	.	.	.	.	+	.	.	.	+
Polygonum bistortoides	.	+	.	.	.	.	.	.	.	+	.	+	.
Potentilla diversifolia	.	0.1/4.0	.	.	.	.	+	.	.	.	.	.	.
Potentilla fissa	.	0.3/10.	.	.	.	.	.	.	.	.	.	.	.
Rosa acicularis	.	0.9/16.	+	.	.	.	.	0.2/8.0	.	.	0.4/8.0	+	0.6/14.
Sedum lanceolatum	+	.	.	.	+	0.3/2.0	.	0.1/4.0	.	.	.	+	.
Senecio integerrimus	.	.	.	.	.	.	.	1.2/16.	.	.	.	.	.
Senecio streptanthifolius	.	0.2/8.0	.	.	0.2/6.0	2.1/16.	0.9/16.	1.8/22.	2.3/22.	+	.	.	.
Silene menziesi	.	.	.	.	.	.	.	.	+	.	.	0.1/4.0	.
Smilacina racemosa	.	.	1.5/18.	+	2.0/20.	0.7/18.	.	0.8/10.	.	.	.	.	+
Solidago missouriensis	.	.	.	.	.	.	.	.	.	.	0.4/4.0	.	+
Spiraea betulifolia	.	13./62.	.	.	0.8/4.0	1.2/2.0	.	.	14./34.	.	.	6.6/50.	3.9/48.
Symphoricarpos oreophilus	.	0.1/4.0	0.4/4.0	0.2/6.0	.	.	.	.	.	.	0.2/12.	8.2/56.	10./70.
Taraxacum sp.	.	+	0.9/16.	.	.	.	.	.	.	.	.	.	.
Thalictrum occidentale	.	.	14./56.	.	.	.	.	.	.	.	.	.	.
Valeriana dioica	.	.	.	.	.	.	0.3/4.0	.	.	.	.	.	.
Viola adunca	.	.	.	.	+	.	.	.	.	.	.	.	+
Zigadenus elegans	.	.	.	.	.	.	.	.	.	.	.	+	0.6/22.

33

Table 6. Undergrowth data of *Populus tremuloides* dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but no in any microplot are indicated by *. Other data included are stand location and topographic position.

Stand Number	61	19	17	10
Location:				
Section	11	36	13	24
Township	50N	49N	48N	48N
Range	84W	84W	84W	87W
Topographic Position:				
Slope	--	10°	--	3°
Aspect	--	115°	--	300°
Elevation, meters	2225	2365	2353	2140
% Coverage	C	C	C	C
% Frequency	F	F	F	F

LARGE SHRUBS

	61 C/F	19 C/F	17 C/F	10 C/F
Artemisia tridentata	.	.	.	0.6 / 6.0
Juniperus communis	4.8 / 10.	.	.	*
Juniperus osteosperma	.	.	.	+
Ribes cereum	.	+	.	0.8 / 2.0
Ribes lacustre	+	3.7 / 16.	.	.
Salix bebbiana	0.8 / 10.	.	.	*

GRAMINOIDS

Agropyron dasystachyum	0.6 / 4.0	0.2 / 8.0	0.8 / 20.	.
Agropyron spicatum	+	4.6 / 40.	+	8.0 / 30.
Carex phaeocephala	0.2 / 8.0	0.2 / 8.0	.	.
Carex platylepis	.	0.5 / 2.0	2.4 / 30.	1.6 / 32.
Carex scopulorum	0.2 / 4.0	+	3.0 / 24.	2.0 / 8.0
Dactylis glomerata	+	.	+	+
Festuca idahoensis	2.0 / 20.	4.2 / 8.0	0.6 / 10.	15. / 40.
Hesperochloa kingii	1.2 / 10.	2.3 / 16.	0.1 / 4.0	2.0 / 15.
Phleum pratense	+	2.0 / 20.	3.6 / 40.	1.0 / 18.
Poa nervosa	1.6 / 22.	5.0 / 36.	4.0 / 40.	1.6 / 28.

LOW SHRUBS AND HERBS

Achillea millefolium	3.0 / 64.	5.0 / 60.	1.1 / 24.	0.4 / 6.0
Allium brevistylum	+	.	0.1 / 4.0	.
Anemone multifida	0.8 / 22.	1.6 / 24.	3.6 / 28.	.
Antennaria rosea	+	0.1 / 4.0	.	0.1 / 4.0
Arctostaphylos uva-ursi	+	.	.	.

Stand Number	61	19	17	10
% Coverage	C	C	C	C
% Frequency	F	F	F	F
Arnica fulgens	.	.	+	.
Astragalus alpinus	.	1.6 / 8.0	12. / 20.	.
Cerastium arvense	.	0.1 / 4.0	+	+
Clematis tenuiloba	.	.	.	+
Fragaria virginiana	4.0 / 40.	5.1 / 48.	3.8 / 52.	.
Galium boreale	0.8 / 30.	5.6 / 48.	+	.
Geranium fremontii	.	.	+	.
Lupinus argenteus	.	10. / 40.	18. / 30.	7.0 / 38.
Lupinus wyethii	.	2.0 / 8.0	20. / 40.	6.0 / 20.
Mahonia repens	.	.	.	1.6 / 22.
Osmorhiza depauperata	+	2.0 / 10.	.	.
Oxytropus campestris	0.8 / 14.	.	+	.
Polygonum bistortoides	0.2 / 8.0	.	+	.
Potentilla diversifolia	3.0 / 48.	.	1.0 / 20.	.
Potentilla fissa	.	.	+	.
Potentilla fruticosa	1.6 / 10.	0.8 / 12.	.	.
Potentilla gracilis	.	+	.	.
Primula parryi	+	.	.	.
Rosa acicularis	1.1 / 22.	.	0.2 / 8.0	.
Sedum lanceolatum	.	.	.	+
Taraxacum officinale	13. / 74.	33. / 96.	22. / 100	12. / 90.
Thalictrum occidentale	.	.	.	0.2 / 8.0
Trifolium sp.	26. / 90.	2.6 / 42.	.	4.4 / 50.
Viola adunca	0.1 / 4.0	.	.	.
Zigadenus elegans	+	.	.	.

34

Table 7. Undergrowth data of *Pinus contorta* dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but not in any microplot are indicated by *. Other data included are stand location and topographic position.

Table 8. Undergrowth data of the *Picea engelmannii*- and *Abies lasiocarpa*-dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. If the species are present in the stand but not in any microplot they are indicated by *. Other data included are stand location and topographic position. Stands are arranged from left to right in order of apparent increasing mesic conditions.

Column group headers (left to right):
- *Picea engelmannii* – *Vaccinium scoparium* H.T.
- *Abies lasiocarpa* – *Shepherdia canadensis* H.T.
- *Abies lasiocarpa* – *Vaccinium scoparium* H.T.
- *Abies lasiocarpa* – *Arnica cordifolia* H.T.

Stand information rows:
- Stand number
- Location: Section, Township, Range
- Topographic position: Slope, Aspect, Elevation, meters

Row labels (species):

LARGE SHRUBS
Acer glabrum
Juniperus communis
Physocarpus monogynous
Ribes lacustre
Ribes montigenum
Shepherdia canadensis
Symphoricarpos albus

GRAMINOIDS
Bromus ciliatus
Calamagrostis scribneri
Carex brevipes
Carex geyeri
Carex heliophila
Carex rossii
Danthonia intermedia
Festuca idahoensis
Festuca ovina
Oryzopsis asperifolia
Poa fendleriana
Poa gracillima
Poa interior
Poa nervosa
Trisetum spicatum

LOW SHRUBS AND HERBS
Achillea millefolium
Agoseris glauca
Allium brevistylum
Anemone multifida
Antennaria racemosa
Antennaria rosea
Antennaria umbrinella
Arctostaphylos uva-ursi
Arenaria congesta
Arnica cordifolia
Arnica latifolia
Aster foliaceus

Stand number

% Coverage
% Frequency

Astragalus alpinus

Astragalus sp.

Campanula rotundifolia

Castilleja miniata

Castilleja rhexifolia

Chimaphila umbellata

Clematis columbiana

Clematis tenuiloba

Corallorhiza maculata

Delphinium bicolor

Epilobium alpinum

Epilobium angustifolium

Erigeron acris debilis

Erigeron formosissimus

Erigeron peregrinus

Erigeron subtrinervis

Fragaria virginiana

Frasera speciosa

Galium aparine

Galium boreale

Gentiana amarella

Geranium richardsonii

Geranium viscosissimum

Geum triflorum

Goodyera oblongifolia

Habenaria unalascensis

Hedysarum sulphurescens

Heuchera parviflora

Hieracium albiflorum

Hieracium gracile

Hieracium sp.

Kalmia polifolia

Lichens and Mosses

Linnaea borealis

Lupinus alpestris

Lupinus argenteus

Mahonia repens

Mertensia ciliata

Mitella pentandra

Moneses uniflora

Stand number: 21, 22, 24, 34, 48, 82, 52, 55, 29, 30, 31, 81, 35, 36, 39, 40, 75, 76, 23, 80, 86, 44, 59, 1, 28, 56, 57, 92, 93, 71, 38, 43, 72, 42, 32, 73, 88, 90, 91, 33, 37, 41, 87, 89, 74

% Coverage / % Frequency — each stand reported as C (Coverage) and F (Frequency)

Species:

- Osmorhiza chilensis
- Osmorhiza depauperata
- Osmorhiza purpurea
- Pedicularis racemosa
- Penstemon rydbergii
- Phlox multiflora
- Potentilla diversifolia
- Potentilla fissa
- Pyrola secunda
- Pyrola virens
- Ranunculus escholtzia
- Rosa acicularis
- Senecio integerrimus
- Senecio lugens
- Senecio sphaerocephalus
- Senecio streptanthifolius
- Silene parryi
- Smilacina stellata
- Solidago multiradiata
- Solidago spathulata
- Spiraea betulifolia
- Taraxacum sp.
- Thalictrum occidentale
- Trollius laxus
- Vaccinium scoparium
- Valeriana dioica
- Veronica wormskjoldii
- Zigadenus elegans

Hoffman, George R., and Robert R. Alexander.
1976. Forest vegetation of the Bighorn Mountains, Wyoming: A habitat type classification. USDA For. Serv. Res. Pap. RM-170, 38 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 80521.

A vegetation classification based on concepts and methods developed by Daubenmire was used to identify 14 habitat types and related phases in the Bighorn Mountains of north-central Wyoming. Included were five habitat types in the *Pinus ponderosa* series, three in the *Abies lasiocarpa* series, two each in the *Pseudotsuga menziesii* and *Pinus contorta* series, and one each in the *Populus tremuloides* and *Picea engelmannii* series. A key to identify the habitat types and the management implications associated with them are provided.

Keywords: Vegetation classification, *Abies lasiocarpa, Picea engelmannii, Pinus contorta, Pinus ponderosa, Pseudotsuga menziesii, Populus tremuloides.*

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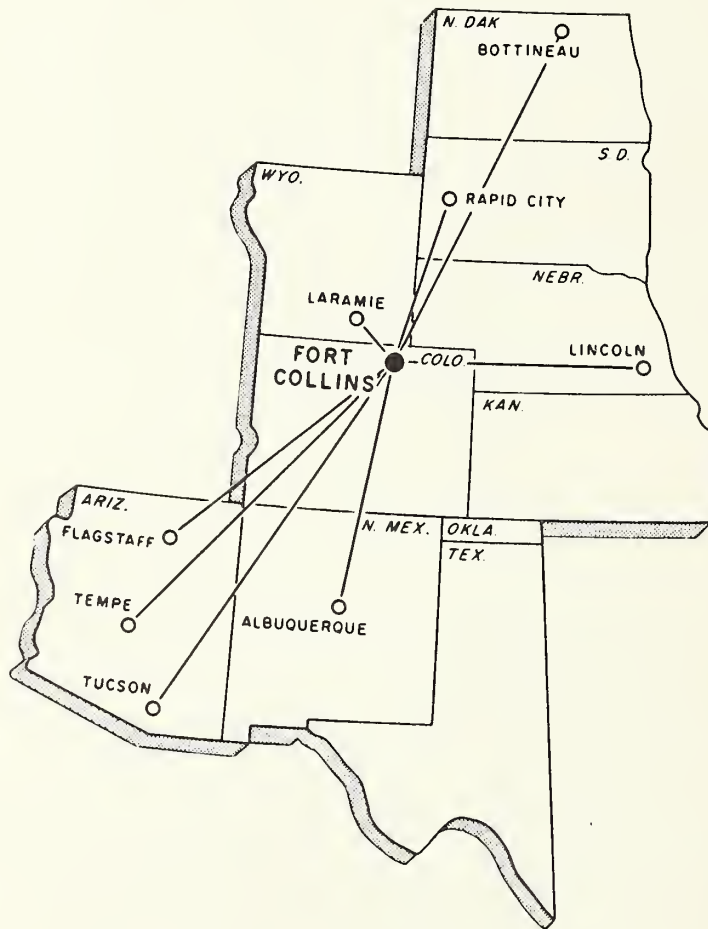
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